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ABSTRACT

The development of a Project for Mathematics Anxiety Reduction Training (Project MART) is described. This Project was designed as an in-service, staff development program for the City University of New York's instructors. The Project is based on the concept that modifying instructor behavior in the teaching of mathematics will lead to lower student anxiety. In addition, pupils should overcome mathematics avoidance reactions and increase their election of mathematics-based curricula. This study describes and reviews the Project, with MART-type workshops recommended for other community colleges. (MP)

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PROJECT MART: MATHEMATICS ANXIETY REDUCTION TRAINING

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in cooperation with the:
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FOREWORD

In the belief that enrollment in postsecondary occupational curricula could be increased, the CASE Institute for Research and Development in Occupational Education (IRDOE) had, for some time, been reviewing the literature and informally surveying students to ascertain reasons for historically low enrollments in certain career programs. Among the most frequent reasons, tacit or openly expressed, were those associated with "dislike" of math or math-based subjects. Further, the literature supported the disproportionate avoidance of math-based curricula by women, largely because of early socialization that depicted certain occupations as being "male occupations."

The project reported on herein is the first, to our knowledge, to approach the issue of math anxiety/avoidance on an in-service, staff development basis. The concept holds that, by modifying instructional behavior in the teaching of math, students will experience less anxiety, overcome avoidance reactions, and experience success which will contribute to election of math-based curricula. Significantly more cost-effective than therapeutic approaches, the "multiplier effect" also promises positive preventive aspects.

Readers are encouraged to communicate their thoughts or experiences to the Institute. Through such sharing significant gains may be made in overcoming a pernicious problem.

Lee Cohen, Director
Institute for Research and Development
in Occupational Education

ACKNOWLEDGMENTS

Again, it is with a sense of pride and pleasure that we approach the best part of report writing: acknowledging the support we received from our staff and colleagues.

We would like to take this opportunity to thank Mr. Mike Van Ryn, Chief, and Mr. Michael King, formerly Assistant in Education, of the Bureau of Grants Administration of the New York State Education Department for their interest in this endeavor. Without such interest, the awarding of grants can be pro forma; that this is not the case with this Bureau has been a continual source of encouragement to us.

As always, Dr. Alan Gartner, Director of the Center for Advanced Study in Education and Dr. Lee Cohen, Director of the Institute for Research and Development in Occupational Education followed our progress and kept us informed of new developments in the field.

The faculty and chairs of Bronx Community College, LaGuardia Community College, Queensborough Community College, and New York City Community College helped in ways too many to detail. We would, however, like to single out the contribution of Dr. J. Juechter of Bronx Community College--without her assistance, many fewer people would have learned about Project MART and fewer would have been involved. Very special mention needs to be made of the backing we received from New York City Community College. In part stimulated by Dr. Lorraine Beitler's enthusiasm (Dr. Beitler is Director of Educational Services) for Project MART, we were fortunate in being able to work with the Office of the President, Dr. Ursula Schwerin, and with Dr. Harry Dunbar (Dean of Liberal Arts) and Dean Ronald Halloway (Division of Technology). We are also indebted to Lou Vigliano, Chair, Developmental Skills; Russ Griemsmann, Coordinator, Developmental Math; and Frank Lasak, Mathematics Department Chairperson.

Unfortunately, we cannot list the names of the faculty and staff who participated in the workshop cycles: a respect for "Human Subjects" denies us the chance to specify the names of the individual participants whose contribution

of time, high level of motivation, and interest in their own professionalism were the real reasons for the project's effectiveness.

Our own staff's efforts on behalf of MART are also noteworthy--although we suspect that many (including the authors) viewed their relationship to the project as a way of working out their own feelings toward mathematics. Ms. Siu Kwan Cheng personally scored the 567 MARS-A tests (math anxiety rating scales), and tabulated and summarized the data. Ms. Ruth Roman-Marrero typed all materials and instruments, leading us to suspect that she was less anxious about the subject at the end than when she started. Ms. Marrero also prepared this document in final form and assumed responsibility for the project's administrative details.

We enjoyed working again with Ms. Carol Florio and Ms. Arlene Vogl whose contributions to Project MART deserve more than a line of thanks. Both, in their own manner, went out of their way in furthering this program. We are grateful for their involvement and hope that they too gained in direct proportion to how very much they put into it.

Finally, we would like to express our appreciation to our consultant, Dr. Stanley Kogelman, Director of Mind Over Math and to acknowledge the fortitude and diplomacy with which he conducted the meetings as well as his creativity in helping develop the materials and program sequence. We have worked with Dr. Kogelman in the past and look forward to as beneficial an association in the future.

Barbara R. Heller

Victor D'Lugin

TABLE OF CONTENTS

	Page
FOREWORD	i
ACKNOWLEDGMENTS	ii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	vii
INTRODUCTION	1
Background	1
Project MART	5
MART: PLANNING AND IMPLEMENTATION	9
Site Selection and Recruitment of Participants	9
First Cycle, Tuesday Afternoons	11
Participants	11
Agenda	13
Second Cycle, Saturday Sessions	13
Agenda	13
Participants	16
Materials	17
MART: CONTENT	19
Content Objectives	19
General Orientation to Math Anxiety	21
Historical perspective	21
Math anxious mathematicians	22
Math anxiety among community college students	25
The Public's Perception of Mathematics	25
"288"	25
Math myths	26
What is math?	27
Computational and Other Specific Problem Areas	29
Word problems	29
Fractions	31
General Pedagogical Strategies	32
Identifying problem students	32
Do's and don'ts	33
Math texts	35
Tests	36
Future Plans	36
Schedule of Topics	37

MART: IMPACT AND PARTICIPANTS' REACTIONS. 41

General Observations 41
Pre- and Postprogram Attitude Changes. 46
General attitudes toward math 46
Being an effective math teacher 49
Solving difficult math problems 49
Assigning course grades 52
Partial credit. 54
Participants' Assessment of Project MART 56
MART's helpfulness. 56
Written materials 57
Overall reactions to the program. 59

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS. 61

APPENDIX A, AGENDA: COLLEGE ORIENTATION MEETINGS

APPENDIX B, RESULTS OF THE MARS-A

APPENDIX C, QUESTIONNAIRES

LIST OF TABLES

No.		Page
1	General Feelings About Math: Mean Differences (Posttest-Pretest) In How Strongly Participants Agree or Disagree With 13 Statements.	47
2	Being an Effective Math Teacher: Mean Differences (Posttest-Pretest) In Participants' Ratings of the Importance of 11 Factors	50
3	Solving Difficult Math Problems: Mean Differences (Posttest-Pretest) In Participants' Ratings of the Importance of 8 Factors	51
4	Computing a Student's Grade: Mean Differences (Posttest-Pretest) In the Importance of 10 Factors.	53
5	Awarding Partial Credit: Mean Differences (Posttest-Pretest) In Participants' Assigning Credit to Each of 3 Incorrect Solutions To 2 Problems	55
6	Participants' Mean Ratings of MART's Helpfulness In Stimulating Understanding or Consideration of 13 Topics . .	57
7	Participants' Mean Ratings of the Usefulness of MART Written Materials	58
8	Participants' Mean Overall Ratings of Project MART on 6 Dimensions.	60

LIST OF FIGURES

No.		Page
1	Workshop Agenda, First (Tuesday) Cycle	14
2	Workshop Agenda, Second (Saturday) Cycle	15

CHAPTER I

INTRODUCTION

Background

In the Spring of 1979, the CASE/Institute for Research and Development in Occupational Education (IRDOE) conducted a four-day program titled, "from SENIOR to FRESHMAN: Career Paths for Women Students in Transition".[1] The program, designed for female high school seniors likely to attend a City University of New York (CUNY) community college in the fall following graduation, was based on the assumption that the after high school plans of many students are fabricated with limited knowledge about and/or exposure to different occupations, curricula and training offerings, and labor market realities. Over and above the pervasive information gap, women students are additionally handicapped by socially imposed sex stereotypes which strongly affect their vocational choices, their assessment of the occupational value of their skills and interests, and their selection of postsecondary courses of study.

Close to half the women in CUNY's community colleges are enrolled in nursing curricula, with an additional 13 and 10 percent in secretarial studies and education/child care, respectively.[2] The minimal representation of women in many scientific and engineering technologies, in the pure or hard sciences, and in certain subspecialities of business and communications is lamentable, for these occupational areas represent new and promising career options for women in fields that are currently experiencing high levels of demand, with equally high future projections. Moreover, many of these are occupations for which community colleges are especially well equipped to provide training.

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[1] B.R. Heller and V. D'Lugin. from SENIOR to FRESHMAN: Career Paths for Women Students. CASE #13-79, 1979. ED 177 370. This project was funded by the Bureau of Grants Administration, New York State Education Department, under the Vocational Education Act (VEA #79-3D-808 DPS.)

[2] B.R. Heller, F. Wheeler, and L. Gross. 1973 Career Graduates: A Profile of CUNY Community College Students. CASE #26-78, 1978. ED 161-470. (VEA #CO77-2-904.) Note that more recent statistics yield similar distributions of female students.

Other than the absence of role models, it has been hypothesized that the underrepresentation of women in these fields is attributable to the prevailing belief that these occupations are too logical, rigorous, and difficult for them. Interestingly, the criteria of logic, rigor, and difficulty seem always to be associated with the progressive study and mastery of mathematics.

For humane as well as legislative reasons, we believe it is important to reverse this trend--to increase the proportion of women in community and senior colleges, as well as in trade schools, who enroll in fields of study leading to careers traditionally dominated by men. To break this pattern of stereotyping occupations by sex, from SENIOR to FRESHMAN offered student participaats experiences identified in the literature as significant and efficacious interventions. Thus, at a crucial transitional point in their development, students received more and better information about available options; cultivated relationships with a wide variety of adult female role models; explored the concepts of personal values, skills, and interests; and dealt with skill-related attitudes and problems, particularly those involving mathematics.

The impact of the three-hour mathematics component (one-eighth of the total program length) was surprisingly strong. Positive changes in students' attitudes toward mathematicians and toward the study of math were evident; equally evident was the desirability of still greater change. While these young women did not appear to be math anxious, they clearly manifested a strong dislike of mathematics.

Recent research into sex differences in the study of mathematics indicates that, starting in junior high school, female students begin to take progressively fewer mathematics courses than do male students. As a result, these women enroll in college poorly prepared in just those basic courses needed to enter (and complete) technological and scientific programs of study. Dislike or fear of math among women is presumed to underlie their avoidance of the subject. Avoidance, in turn, effectively filters many women out of math- or science-based college curricula, for which they, typically, must make up a substantial number of math courses just to catch up with their male counterparts.

Although dislike of mathematics is not an exclusively "female" phenomenon, avoidance of math tends to be. Sells' investigation of the relationship between high school math preparation and college curriculum found that among the top 12.5 percent of high school graduates admitted to the University of California at Berkeley in 1973, 43 percent of the entering men and 92 percent of the entering women did not have a sufficient number of courses in mathematics to pursue most of the majors offered at the University, except for programs in the humanities, music, elementary education, and social work, guidance and counseling.[1]

Our own research supports a similar relationship between mathematics and choice of major. As part of the from SENIOR to FRESHMAN program we administered a questionnaire to more than 300 prospective high school participants near the end of the first semester of their senior year. Three out of 10 indicated that their worst subject was mathematics, and an additional 22 percent listed a math-based science course. Perhaps as importantly, almost 40 percent of the respondents were not currently enrolled in either a math or a science course, and another 12 percent who were enrolled in a science course were not taking mathematics. (It should be noted that included among the math and science courses the respondents were enrolled in, were courses such as recordkeeping, health, and child care.[2]) Although these data do not tell us why students were avoiding math (e.g., a dislike for the subject, a general nonacademic orientation) it is clear that these women would enter two-year colleges without the mathematics prerequisites for most of the high-demand nontraditional careers.

Concern with attitudes toward mathematics, and the effects of attitude on performance, has only recently begun to gain the attention of a wide audience. A 1974 study by Hilton and Berflund exemplifies the research findings on this topic.[3] Following the same students from grade 2 through

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[1] Lucy W. Sells. Mathematics--A Critical Filter, The Science Teacher, February 1978, 45 (2), 10-12.

[2] from SENIOR to FRESHMAN, op. cit.

[3] Thomas L. Hilton and Gosta W. Berflund. Sex Differences in Mathematics from Early Elementary School to College Levels, Journal of Psychology, 1977, 97, 47-256.

college, they found no sex difference in achievement up through grade 5. By grade 7, however, males began to show higher achievement scores. Similar findings are reported in terms of attitudes, with females exhibiting more negative attitudes than males toward math, but only after the ninth grade. Another study found that although both males and females exhibited increasingly negative attitudes toward math as they progressed through school, females' attitudes worsened more than those of the corresponding males.[1]

When we look at the research findings on sex differences in attitudes toward math, in achievement in math, and in background preparation, it is apparent that an interrelationship exists among them. Despite the fact that both girls and boys form negative feelings about math fairly early in their educational careers, the effects are most deleterious for females--a difference easily attributable to sex role stereotyping. Bypassing their own feelings, males respond to the social expectation that they should be interested in math and science, continue to enroll in these courses and to achieve a respectable mastery. Society's expectation that women do not have to be interested in these disciplines, by reinforcing the negative feelings female students may have about these subjects, permits (if not encourages) them to work less hard in required courses and/or avoid the non-required ones.

Many individuals, especially women, who evince outstanding ability to reason abstractly in other fields report intense anxiety and blocking when dealing with math. Math teachers have probably always been aware that many students of both sexes do not like mathematics. Teachers constantly note people "tuning out", unable to take in any information. It is only recently that this phenomenon has been labeled (math anxiety, math avoidance, math phobia) and its differential effects on the career choices of men and women acknowledged.

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[1] Ralph D. Norman. Sex Differences in Attitudes Toward Arithmetic-Mathematics from Early Elementary School to College Levels, Journal of Psychology, 1977, 97, 47-256. Also see: Elizabeth Fennema and Julia A. Sherman. Sexual Stereotyping and Mathematics, The Arithmetic Teacher, May 1977, 369-372.

In 1979 an Ad Hoc Committee of the National Academy of Sciences was formed to consider the current state and future requirements of the mathematics curriculum in colleges and universities. Special attention was given to the need for all students to be able to use and apply selected mathematical concepts. One of the Committee's conclusions was that " the principle problem is one of attitudes". Their final report states "we have been made aware of the widespread existence of attitudes that must be substantially modified if students are to be encouraged to view positively the prospect of a career devoted to the use of mathematics in the solution of problems that arise in science, in industry, or in government service".[1]

Project MART

When the Bureau of Grants Administration (New York State Education Department) called for proposals and made public its priorities for the 1979-80 year, we proposed (and were awarded a grant for) Project MART, Math Avoidance Reduction Training.[2]

Our purpose was to design an efficient and effective way to deal with the math anxiety-avoidance problems of large numbers of community college students, particularly the vast majority of students whose problems are not pathological. Moreover, we wanted a program that placed no additional burdens on either the student or the educational institution, and an approach both interpersonal and skills-based that, if successful, could be disseminated. We also felt there was little need to replicate other peoples' therapeutic approaches (since these do not meet our criteria), although nearly all of these counseling-based programs deal with four-year college students and not directly with vocationally-oriented community college women.[3] The result of

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[1] Ad Hoc Committee on Applied Mathematics Training, Assembly of Mathematical and Physical Sciences, National Research Council. The Role of Applications in the Undergraduate Mathematics Curriculum. Washington, D.C.: National Academy of Sciences, 1979, p.1.

[2] VEA #80-3E-56 GPS.

[3] For a description of these programs, see S. Kogelman and J. Warren. Mind Over Math. New York: McGraw-Hill Paperback Edition, 1979. Also see S.Tobias. Overcoming Math Anxiety. New York: W.W. Norton & Company, Inc., 1978.

our design is a staff development workshop program for two-year college math faculty (and faculty of math-related subjects) that addresses students' negative attitudes toward math by modifying in-class teaching strategies and pedagogical techniques.

MART reflects the assumption that many of the factors contributing to anxiety-avoidance behavior are related to the style and nature of instruction and to conceptual understandings shared by the mathematicians but not necessarily by the general public. Project MART, therefore, proposed to introduce community college faculty who teach mathematics (or math-based courses) to, and examine with them, techniques that had proven effective in reducing or alleviating student math-avoidance behavior, thereby increasing their awareness of how math anxiety is inadvertantly reinforced in the classroom and providing them with alternative teaching procedures. Focusing on the instructor and her/his activity in the classroom, would allow us to reach a larger pool of students and assure that any advances would remain on-campus in the form of a cadre of knowledgeable people trained in new pedagogical approaches.

In essence, Project MART is a student-centered program. Improved classroom instruction, which results in decreased anxiety should, in the long run, produce a concomitant increase in the number of students (of both sexes) who enroll and remain in occupational programs that require more than a minimal level of mathematical ability.

The immediate goals to be achieved in the one-year demonstration period covered by the grant were: to increase community college instructors' awareness of and sensitivity to students' feelings about math; to provide these faculty with an open but structured setting in which to explore and perhaps clarify attitudes and modify behaviors which may affect their students' performance; and to improve the climate for the learning of math and induce a more positive response on the part of students.

To achieve these objectives, for the 1979-80 year MART sought to:

- introduce community college mathematics faculty (and other faculty who teach math-based courses) to the concepts of math anxiety-avoidance; explore with them its determinants,

prevalence, and implications in terms of limiting students' occupational options;

- assist community college math faculty in clarifying their own attitudes toward mathematics, teaching, and the community college student;
- increase faculty awareness of the vocational implications of math avoidance;
- increase the awareness of community college faculty of how they may inadvertantly reinforce students' negative attitudes toward math by the use of certain classroom techniques, traditional textbooks, and choice of example problems;
- train community college faculty to recognize the symptoms of math-anxiety in the classroom;
- provide faculty an opportunity to learn or relearn (through simulation and example) alternative strategies and techniques that have proven successful in reducing or alleviating math anxiety;
- improve the climate for students in math classes by providing faculty on-going, immediate support and materials for use in the classroom; and
- assemble a cadre of faculty with interest in and aptitude for training other faculty from the colleges, or for establishing other activities to identify and meet the math needs of individual students.

During 1979-80, Project MART operated two workshop cycles that involved people from four different CUNY community colleges (and one non-CUNY private college): 28 math instructors, one instructor of physics, and one guidance counselor participated. The first cycle, from February through May, was conducted at one of the CUNY community colleges and was open only to faculty and staff from that institution. The second cycle, which began in April, took place on four consecutive Saturdays at the City University of New York's

Graduate School and University Center and was open to faculty from several campuses.

The remainder of this report describes and assesses the program content and structure of the MART pilot demonstration.

CHAPTER II

MART: PLANNING AND IMPLEMENTATION

A workshop format, permitting face-to-face interaction, immediate and flexible response to new developments and participants' needs, and variation in style of the presentation of materials, was decided on as the structure best suited to meet Project MART's goal of working with mathematics faculty to design new instructional approaches that would reduce the moderate to high level of math anxiety presumed to characterize community college students.

Site Selection and Recruitment of Participants

As originally proposed there were to be two demonstration colleges that served a large proportion of disadvantaged students, demonstrated a departmental-level commitment to the project, and had a sufficiently large faculty from which we could recruit interested participants. Participation was to be limited to faculty of those institutions in order to develop a cadre of people who shared a common orientation.

Starting in early September, project staff talked with chairpersons of several mathematics departments. In these discussions, we described the program in some detail, outlined mutual obligations (e.g., theirs included making space available and supplying some A-V support services), asked for input on structure and content, and explored the degree of their support. In general, the response was positive and a willingness to continue negotiations was evident. The initial discussions led to more formal orientation meetings at two CUNY community colleges. A copy of the agenda for these meetings is appended (see Appendix A.)

Both orientations took place in the late Fall and involved project staff, our math consultant, mathematics department faculty, representatives of math-related departments, and college administrators. In addition to providing an overview of the project, some background on math anxiety, and a description of our expertise and previous experience in the field, two important organizational details were addressed at these meetings. The first concerned scheduling--

determining the days on which the workshop could be held that would attract the largest number of people. The second concerned what would be expected of participants--approximately 20 hours of workshop time after classes, at least an equal number of hours spent reviewing materials for use in their classes, and, the administration of a mathematics anxiety rating scale in some of the math sections they taught.

The registration form asked faculty for some descriptive information about courses currently taught, where they could be reached, and to rank order different possible workshop schedules. (The schedule options included several specific weekdays, times of day (morning, afternoon, early evening), frequency of sessions (one 2 1/2 hour session per week for eight weeks or four sessions of 5 hours each, and a Saturday vs. a weekday alternative.) They were also asked to state their preference for having the program at their campus or at CUNY's Graduate School and University Center in Mid-Manhattan.

Both orientation meetings proved provocative to faculty and project staff. Many faculty seemed very interested in the program, and several indicated that they had not been aware of the extensive work being done on math anxiety. However, a substantial number objected to the program's basic premise that large-scale remedies involved a modification in the way mathematics is taught. Many faculty suggested instead that the solution involve students and counselors, echoing the belief that the difficulty was solely with the learner. Although we did recruit the targeted number of participants, this reaction was the first definitive sign of faculty resistance.

One result of these orientation meetings was a change in the proposed plan. At one college we were successful in recruiting a large number of interested faculty. At the other college we were not: fewer people were interested, and more importantly, it was apparent that the program would not receive the administrative support we required. While deciding whether to approach our first alternate college, we began to get calls from people asking about MART and expressing a desire to take part in the program. Information about the project was circulating, partly due to our initial discussions and partly a result of word of mouth. On the strength of this generalized interest we

modified our design: instead of two workshop series each conducted at one site exclusively for that college's staff, we would run one cycle as planned, but open the second series to people from several different institutions. Based on faculty scheduling preferences, the modified design probably accommodated more people. Under the new design, one workshop series (hereafter, the first cycle) was conducted at one community college on eight Tuesday afternoons, starting on February 26, 1980. However, because of the Spring recess, followed by the New York City Transit strike, the eight Tuesday afternoon sessions actually covered a period of 10 weeks--from February 26 through April 29, 1980. The second cycle was held at the CUNY Graduate School and University Center, on four consecutive Saturdays (beginning April 19 and ending May 10), and involved staff from different colleges, including persons from the first-cycle college for whom Tuesday afternoon was an impossibility. Each cycle consisted of approximately 20 hours of workshop time: each of the eight Tuesday meetings ran about 2 1/2 hours; the four Saturday meetings for five hours (excluding lunch). A calendar of dates and daily agendas appears on page 14 and 15.

To maintain interest during the interval between the orientation session and the start of the workshop series, we wrote to participants frequently. First, all faculty who completed a registration form received a thank you note explaining that we were working out a schedule. When the schedules were set, we informed them of the dates, times, and locations, including in this letter a copy of an article by Aiken[1] (a survey of the literature on sex differences and math anxiety), a cartoon about mathematics (part of the collection we compiled to illustrate how the general public views mathematics and mathematicians), and a request to bring to the first session any of their own favorite anecdotes, jokes, or cartoons. The last pre-workshop communication was a reminder letter, mailed 10 days before the first session.

First Cycle, Tuesday Afternoons

Participants. A total of 18 faculty from the mathematics departments of one CUNY community college were invited to participate in the first cycle of

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[1] L.R. Aiken, Jr. Update on Attitudes and Other Affective Variables in Learning Mathematics. Review of Educational Research, 1976, 46 (2), 293-311.

Project MART. Of these, 16 attended one or more of the eight afternoon sessions, and 12 (including the two department chairpeople) attended them all.

This community college has two separate math departments, each chaired by a different person: a regular Mathematics Department and a Developmental Skills Department, responsible for remediation in math, reading, and writing. Together with the college's administration, we had decided to invite faculty from both departments. Both departments were represented in the program by instructional staff and by their respective chairpeople. Interestingly, of the six people from the Developmental Skills Department, three preferred teaching remedial level subjects and disliked teaching more advanced math courses. Of the 10 people teaching in the regular Math Department, three liked teaching basic math courses--but most did not.[1] Overall, first-cycle participants had an average of 11.7 years (median = 9) of teaching experience at the college level.

As is typical of most community college faculty, 13 of the 16 participants held master's degrees--in math or math education--and the remaining three had earned a doctorate (two in psychology and one in physics). Seventy-six percent (12) had undergraduate training in mathematics; the others in statistics, physics, engineering, and psychology. When asked whether they were currently pursuing additional training (i.e., doctoral level), seven said they were--in education (4), statistics (2), and mathematics (1). While none of the people teaching developmental math anticipated a future career change, half of those teaching regular math courses did. Almost no one in either group indicated that they had seriously contemplated giving up the study of math, despite the fact that they openly said that they found particular topics or subjects difficult.

As a group, the Tuesday participants decided to become math instructors primarily because they enjoyed math themselves and tended to do well in it. Math was, by far, the subject they liked best in high school, followed by (in order of decreasing enjoyment) the physical and chemical sciences, the biological and natural sciences, English and literature, history and social studies, and foreign languages. Six had dropped or withdrawn from a math

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[1] These, and the other descriptive data in this chapter, are based on the Survey responses of all people who started the program.

course after high school because the course either required too much time or because of its difficulty. Eleven respondents had gotten at least one C or D in a math course--although apparently these grades did not affect their decision to teach. Nine of the 16 participants decided on mathematics as a profession by the time they had graduated from high school. All tended to rate their high school math teachers somewhat better than their college instructors. Confirming our assumption that mathematicians also experience anxiety, the participants indicated they were somewhat more anxious taking tests in math than they were taking tests in other subjects; this was especially true for the faculty currently teaching in the regular Mathematics Department.

Agenda. Figure 1 on the following page, summarizes the daily agenda for each of the eight Tuesday afternoon sessions. Generally, the topics were covered in the order planned. Variations made in response to the reactions of participants will be discussed at the end of Chapter III which describes the workshop content.

As implied, attendance tended to be stable after the second meeting. Sessions started and ended on time, with few participants staying late to chat with project staff and consultants. Refreshments--coffee and cake--were provided at each meeting by arrangements made with the college's caterer. Although every attempt was made to keep these meetings informal and lively, they tended to remain formal (with, for example, participants raising their hands for recognition) and somewhat static. This was in direct contrast to the behavior of the Saturday cycle participants, and some possible reasons will be advanced in the final section of the report.

Second Cycle, Saturday Sessions

Agenda. Figure 2, on page 15 , presents topics in the actual order discussed by the second cycle participants. As can be seen, the sequence varied from that used in the first cycle. Since the second cycle did not begin until the first was almost completed, we were able to reschedule topics

Session	Date	Content
1	February 26	What is math anxiety? (short introductionary review) My students My math anxiety Public Image of Mathematicians
2	March 4	Math Myths Implications of Believing Math Myths Word Problems and the Direct Translation Method Introduction to Testing
3	March 11	Results of the MARS-A (Math Anxiety Rating Scale) administration Characteristics of Math Anxious Students (with videotape) Some Thoughts on Teaching Fractions
4	March 18	Fractions, continued
5	March 25	Some Thoughts on Teaching Algebra Testing, Test Construction, Test Preparation, and Grading
6	April 15	Some Thoughts on Teaching Signed Numbers Grading, continued Reading math texts Evaluating math texts
7	April 22	Future plans: Math clinics Do's and Don'ts in Classroom Teaching
8	April 29	Future plans: Proposal writing Conclusion and summary

Figure 1: Workshop Agenda, First (Tuesday) Cycle

based on experience. Other variations, however, are accounted for by differences between the two groups of participants and the increased length of the second cycle day. We will return to participants' reactions to the program's content in Chapter III and IV.

Session	Date	Content
1	April 19	What is math anxiety? (short introductory review) My math anxiety My students Word problems and the Direct Translation Method Public Image of Mathematicians What is Math?
2	April 26	Characteristics of the Math-Anxious Student Math Myths Implications of Believing Math Myths Some Thoughts on Teaching Fractions Do's and Don'ts in Classroom Teaching
3	May 3	Videotape Some Thoughts on Teaching Algebra Reading math texts Evaluating math texts
4	May 10	Some Thoughts on Teaching Signed Numbers Future plans: Dissemination Strategies; Math Clinics; Proposal Writing.

Figure 2: Workshop Agenda, Second (Saturday) Cycle

Saturday sessions were held at the Graduate School and University Center. The meetings started promptly at 9:30 a.m. with coffee and light refreshments; broke for lunch, which we arranged; and ended at 4:00 p.m. or later, since many people chose to stay, talk, and help project staff clean up. Illustrative of the difference in ambiance, Saturday participants baked bread and bought cakes to share with the group.

Participants. In contrast to the first cycle, the Saturday series included faculty and staff from four CUNY community college and one private four-year college in New York City. We invited a total of 17 people who had expressed interest in MARS; 14 came to at least one session, with 11 (including 1 counselor, 1 physics professor, 1 prison math instructor) participating in all four of them.

As was the case with first-cycle participants, 10 (72%) of the 14 faculty who came on Saturdays had masters' degrees (in math, math education, computer science, physics, or psychology), and the other four respondents a doctorate--in math education (3), and in educational administration (1). Seven of those with an advanced degree said they were currently pursuing a doctorate--in math education (4), operations research (1), psychology (1), and physics (1). The group's undergraduate training was also more diverse than that of the first cycle, with only eight of the 14 (58%) having been math majors. All but one of the 14 were currently teaching mathematics--nine of them taught precollege level subjects, including remedial math. The average number of years they had been teaching math at the college level was 8.1 (median = 9)--3.6 years less, on the average, than the college teaching experience of the Tuesday participants.

As a group, their best liked subject in high school was math, followed by the physical and chemical sciences, English and literature, foreign languages, biology and the natural sciences, and history and the social sciences. Their preferences are clearly different form those of the Tuesday afternoon participants. Only one had ever dropped or withdrawn from a math course (because it was "too hard"), although eight had received C's and/or D's in some graduate or undergraduate courses. Five participants (39%) anticipated a career change sometime in the future, but similar to the Tuesday group, 11 had decided on math as a profession well before high school graduation. They too made this

decision because of their own successes in and enjoyment of math--especially because of the "very logical and consistent nature of the subject". Again, their high school math teachers were rated more positively than their college instructors.

In marked contrast to the first cycle participants, those who attended the Saturday program tended, overall, to be less anxious taking a math test than taking a test in other subject areas--this despite the participant who said that maybe the anxiety he "experienced in English could be avoided if [he] majored in math".

Although the participants in both cycles appear to have differed from one another in several ways (including several that might help to account for other differences between the two cycles), it was their similarities that reinforced our choice of program content. For example, Project MART stressed pedagogical and classroom management techniques on the assumption that most community college instructors have not had this type of training. Indeed, this was true of the MART participants. Most had majored in math at the undergraduate level; none had majored in education and only two majored in math education where pedagogy is usually introduced. Those participants doing advanced work in math education will receive at least some of this.

Materials

As we have done in the past, project staff prepared an extensive set of written materials both for our own and the participants' use during the program and afterwards.

A script was developed to assist the consultant and senior project staff lead the sessions. Our intent was to work toward the design of a program that could be replicated by others or easily adapted for self-instruction; therefore, the script included a detailed scenario of each session and included objectives, sample monologues, examples, and/or illustrations; as well as the rationale for the selection and sequence of activities and topics. Since the

consultant shared the sessions' leadership with the project's staff, the script also helped us coordinate our approach and emphases.

Materials for participants were also created. Those designed to stimulate advance thinking about and preparation for a particular topic were distributed at the session preceding the one in which they would be used. Exercises--math problems designed to illustrate a particular topic or simulate a specific situation--were introduced during sessions in which they were used. Summary materials, intended to remind participants of what had been accomplished and to list the highlights of a new technique so that they could be remembered for use in the classroom, were distributed at the close of each session. As anticipated, participants' very favorable reactions to these materials, confirmed our belief that they would be particularly receptive to the written word.

An evaluation instrument was administered to participants at the first and last sessions. In addition to demographic data, it included questions relating to attitudes and teaching and grading policies. Pre- and postprogram comparisons are discussed in Chapter IV, following a description of the program's content.

CHAPTER III

MART: CONTENT

Final decisions about the content of the MART program were arrived at after a review of the relevant literature and extensive deliberation and consultation among project staff and consultants. We involved, among others, a nationally recognized expert in math anxiety who, in addition to assisting in the selection of topics, review of plans, and drafting of materials, also led the workshop sessions.

Content Objectives

The growing body of work in the areas of math anxiety/math avoidance has yet to be integrated and synthesized. While the state of the current knowledge is sufficient to permit some working hypotheses, any claim that the terrain is understood adequately enough to form the basis of definitive programmatic action is premature. Thus, one of our internal goals for Project MART (and one of the outcomes of the present demonstration) was to identify and organize the content and sequencing of the information pertaining to math anxiety/math avoidance.

In addition to making programmatic "sense" of the extensive literature (much of which appears in popular publications), we faced two other problems. First, much of what is known about math avoidance is based on work done at prestigious, private four-year colleges and universities, among self-selected math-avoiders participating in math clinics run jointly by mathematicians and counselors. Our ultimate target population was CUNY community college students enrolled in career programs. To reach large numbers of these students, who we believed could benefit from assistance in modifying their attitudes toward and experiences with math, meant working directly with community college math faculty. Our prior experience at the local two-year colleges led us to anticipate that, at best, our faculty would be minimally aware of the extent or pervasiveness of math anxiety and, at worst, perhaps justifiably skeptical that it existed at all. We presupposed that, as mathematicians, they would not necessarily be familiar with the problem as described in the popular press

and would want introductory and supporting data, as well as specific suggestions and procedures that they could try out in class. The program's content, therefore, had to be comprehensive in scope, sufficiently concise to be communicated in a reasonable amount of time, and compelling (that is valid) enough to lead to adoption. Furthermore, the presentation had to take cognizance of an underlying but unspoken assumption that, just as poor teaching is one of the factors contributing to the formation of math anxiety, good teaching may be one of the factors in its cure. Given the programmatic emphasis on a therapeutic model for working with math anxious students, we were in effect plowing new ground by stressing in-class, curricular-related procedures and directing our efforts to modify faculty behavior (as opposed to student behavior.)

After reviewing the vast array of mathematical concepts and topics, we established three criteria for the inclusion of content. First, of course, all content must directly correspond to the program's general goals for participants: the acquisition of new understanding and knowledge concerning the cause and effects of dislike and/or fear of math, and an appreciation of teaching techniques instrumental in helping to overcome or diminish students' negative attitudes and past experiences. Community college faculty while well prepared professionally in their discipline (i.e., in mathematics) generally tend to have had little training in pedagogy, in classroom management techniques, or in specific teaching strategies for dealing with their student population in either regular or remedial settings.

Second, the program's content would need to induce and maintain participants' interest by appealing to their current teaching responsibilities and their own professional development. Participation in Project MART was voluntary and no tangible incentive was to be offered to faculty for attending: a workshop cycle involved a total of 20 hours, evenly divided among eight afternoons or four Saturdays; in addition, each participant was asked to devote time to experimenting with the material covered. It was, therefore, crucial that the program appeal to personal interests.

Finally, content was partially dictated by the program's format and by the need to vary topics while maintaining a logical flow from one to the next. We decided the best structure for this pilot endeavor would be a peer workshop

where we might gather as much information about math anxiety at the community college level as we would be disseminating. This meant we had to be concerned with ways to actively involve all participants and comfortably juxtapose their varied teaching styles. In this setting, the program's credibility would be enhanced by employing a mathematician as group leader--because he would command the respect of the academicians, and also serve as a convincing model to demonstrate how mathematical manipulations might be handled differently in the classroom.

After reviewing the available materials and suggestions from experts and faculty, we selected five major content areas, each comprising a number of topics. The remainder of this chapter describes each of the topics and the materials we produced for use in the 1979-80 field try-out of Project MART. The following summary does not correspond to the order of events as discussed in Chapter II, nor to any order of importance; the sequence reflects instead, the developmental stages the staff went through in its design.

General Orientation to Math Anxiety

Information about the full force and implications of math anxiety/avoidance behavior are not yet widespread. Thus, to set the stage and to convey some of the urgency of the problem we felt it was necessary to discuss the work that has been and is being done throughout the country. Three sub-topics describe the conceptual and empirical background of math anxiety.

Historical perspective. First, we summarized the research and the history of program development. This historical overview covered the early work in the field (starting in the late 1950's) up through the present efforts taking place nationally. Special emphasis was placed on findings and programs dealing with college-age and adult populations, but attention was also given to what has and is taking place at the secondary level. Because the nature of this topic called for a didactic presentation, we divided it into a short introductory statement for the first workshop session (What is Math Anxiety?), and a lengthier presentation (Intellectual Foundations) for a later session. Project staff prepared and distributed a summary of research and an annotated bibliography, Additional Readings, so that participants would have additional references.

Math anxious mathematicians. A second topic, introduced early in the program, spoke to the participants' own math anxiety. The literature suggests that all or nearly all people (including mathematicians) experience dislike, discomfort,or self-doubt at some time in their mathematical education, or subsequently. The workshop leader led the way by talking about his own anxiety-provoking experiences as a way of getting participants to express theirs. The intent of this discussion-exercise was to dramatize and hence, clarify the emotions and behaviors of community college students by drawing a parallel between what they feel and what the instructors experience. In addition, we wanted participants to view math anxiety as a continuum of behavior, ranging from mild discomfort (the form most likely to be experienced by the mathematician on certain occasions) to extreme phobic reaction (experienced by some people whenever they are confronted with numbers or computations.) We hoped that by confronting their own, albeit mild anxiety, MART instructors would better appreciate their students' reactions even when faced with what teachers believe to be a "simple" math problem or conceptual formulation. To maximize the possibility of this recognition, one of the word problems used in a later session was purposefully created to be difficult and anxiety-provoking for experienced mathematicians. It had one desired effect--participants at least became anxious if not more sympathetic.

Math anxiety among community college students. The final general orientation topic concerned math anxiety at the community college level. In February 1980, at the beginning of the first workshop cycle, we asked for faculty volunteers to administer the Mathematics Anxiety Rating Scale, Form A (MARS-A) to students in remedial, entry level, required, and advanced math classes. These results will be described below. [1] We decided to have the

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[1] Similarly, the second workshop cycle participants were also asked to administer the MARS-A to selected classes of students; a total of 180 students in 15 classes were tested. However, since they were in different institutions and we could not match classes, these data will not be described in the body of the report; class means and distributions were returned to the instructors, and the results are appended. (See Table B1, Appendix B.)

MARS-A administered for two reasons: first, to begin in a systematic way to ascertain the level of math anxiety among community college students--a population not mentioned in the literature. And second, to illustrate to faculty just how severe and prevelant math anxiety is among their students. Collecting and discussing the results accomplished both aims.

Before introducing the findings to the participants, time was devoted to discussing students' ability levels, reactions in class, and instructors' pet peeves. As well as allowing participants to give voice to their opinions, this discussion also helped project staff generate new ideas and consider new additions to the program. The stimulus for the discussion was an 11-minute videotape of high school seniors discussing their feelings about and reactions to math teachers, texts, and common classroom activity.[1]

The MARS-A, developed by Richard M. Suinn, is a 98-item self-rating scale that purports to measure one's anxiety when performing certain tasks or when confronting certain situations that require computational skills.[2] Students (subjects) are instructed to rate each item on a five point scale (from 1 = not at all anxious, to 5 = very much anxious or apprehensive); ratings are to be made on the basis of present feelings. The total raw score could range from 98 (or, "not at all anxious" if each item was rated 1) to 490 (or, "very much anxious", 5 on all items) In the interest of simplicity, we calculated an average score by dividing the total raw score by the number of items completed.

The faculty participating in the first workshop cycle administered the MARS-A in 20 different sections in one college: in 10 developmental (remedial) courses and 10 regular math courses, ranging from basic, required to advanced, elective courses. More than 400 students were tested, and the results are

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[1] This videotape was edited by project staff from footage shot during the from SENIOR to FRESHMAN program segment involving the interaction of women students and mathematicians.

[2] R.M. Suinn. Mathematics Anxiety Rating Scale, © 1979. Published by the Rocky Mountain Behavioral Science Institute, Inc.

based on an N of 387 (206 males, 181 females), all of whom answered at least 95 of the 98 items. The average or mean scores for all sections of a given course, for all developmental courses, and for all regular math courses are presented in Table B2, Appendix B. Also included are difference scores and their significances. In examining the results in detail, two points should be kept in mind: the higher the score, the greater the level of anxiety; and, these results were obtained from tests administered at only one CUNY community college. (Table B1, Appendix B, summarizes the results derived from the MARS-A administration by the second cycle workshop participants.)

As Table B2 clearly shows, students in developmental math courses were more anxious than those in regular math courses; the mean difference between these two groups is significant at better than the .001 level of confidence. Males in developmental math are more anxious than males in regular math, all sections combined (p = better than .01), as are the corresponding females (p = better than .001.) There also appears to be an overall negative relationship between degree of anxiety and level of the course: the more advanced the course, the less anxious the students.

This is not to imply that the students in regular math courses at this particular community college are not anxious about math. On the contrary, their scores fall between being "moderately" anxious to slightly more than "a little" anxious on the scale. In contrast, however, the developmental math students rate themselves as more anxious, with scores ranging between "a little" and "a fair" amount of apprehension.

What about sex differences? In six of eight courses (all sections combined) women were more anxious than men although these differences were not statistically significant for either remedial or regular courses. Only when all women were compared with all men (combining both remedial and regular classes) was the difference significant.

In terms of Project MART, these data point to the existence of a goodly amount of math anxiety among community college students, and especially among those in need of remediation. The results also suggest that women tend to be more anxious than men, and that their higher level of anxiety may be associated with (and perhaps causative of) math avoidance. Looking at the Ns in Table B2,

it is apparent that the distribution of males and females in developmental math courses approximates the sex distribtuion in the general CUNY community college population (61 percent female). This, however, is not the case in regular math courses, where males outnumber females by more than 2 to 1. From these numbers alone, it is obvious that disproportionately fewer females are enrolling in the advanced math courses--those required for traditionally male career areas.

The Public's Perception of Mathematics

This topic was of considerable interest to us. How is mathematics viewed by the general public? In what ways (if any) do their perceptions differ from those of mathematicians? By the time they enter high school, most people have acquired a number of beliefs about how math is done, learned, or mastered. Since many of these beliefs can be shown to affect student performance, it was important to alert faculty to the prevalance of these negative and disabling points of view. To this end, the following three topics were included in the program.

"288".[1] To stimulate discussion of the "Public Image of Mathematics and Mathematicians", project staff compiled an extensive anthology of jokes, cartoons, and anecdotes about math and mathematicians which was distributed to participants. By introducing some lightness to the subject, we hoped to encourage faculty to talk about how others reacted to them in social or in work situations when they learned they were talking with a mathematician. Most could describe instances in which others' reactions were negative or incredulous; one female faculty member said she never told people what she taught. The consensus was that nonprofessionals do not see math as beautiful nor interesting, but as a cold, inhuman, insensitive subject and attribute many of the same characteristics to mathematicians, viewing them as uninteresting people whose idea of a good time is curling up with a good statistics book.

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[1] Two Gross (too gross?)

Math Myths. This topic dealt with some commonly shared generalizations about how math is done. Aptly titled Math Myths, discussion focused on 12 statements presumed to characterize the mathematical person and process,[1] such as: men are better in math than women; math is not creative; and some people have a "math mind" and some don't. Myths such as these have become part of our folklore and have direct bearing on learning behaviors and expectations. The reason for introducing these myths was not to debate their veracity (or rather, lack of veracity), but to center attention on the consequences for both learner and teacher of believing in them. A summary of these implications, entitled, "If you Believe...Certain Math Myths", was prepared and distributed to participants. As an illustration, if you believe that men are better equipped to do math than women, it might follow that:

-As a woman, you accept (as a part of the concept of being female) that you can't do math and therefore stop trying;

-As a woman, you are allowed and allow yourself to avoid math, severely limiting your vocational and education options;

-As a woman, you become dependent on others (usually men) to do your math, including handling your finances; and

-As a man, you put women down by indicating that you don't really expect much of them either in the classroom or in math-related activities on the job.

Similarly if you believe that there is a special "math mind", each failure or frustration tends to confirm that you don't have it; as a result, you are apt to go to others for help, instead of trying to figure things out yourself; and believing that mathematical ability was somehow biological or genetic, you would give up when math didn't come easily without putting in the time and effort that mastering math requires.

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[1]These Myths were taken from Mind Over Math,© op. cit. and used with permission of the author.

Like the discussion of the public's image of mathematicians, discussion of math myths was intended to increase participants' awareness that these (and other) generally accepted stereotypes about mathematics have counter-productive effects on the acquisition of knowledge and improvement of skills.

What is Math? Many of the characteristics or qualities of mathematics that excite or stimulate mathematicians and good math students are either unappreciated or misunderstood by the majority of students--and certainly by the math anxious ones. To emphasize this point, four characteristics of mathematics were delineated, and the workshop discussion centered on how these qualities affect teaching and learning. These four qualities are: (1) progressive conceptual leaps; (2) cummulative nature of mathematics; (3) right or wrong answers; and (4) elegance and beauty of mathematical logic and procedures.

Learning mathematics often necessitates dealing with conceptual leaps of faith. To deal with these temporary "black holes", the learner must suspend disbelief and continue working toward a solution or resolution, despite a feeling that the problem is impossible or that there is insufficient information for a solution. By working at the problem and a number of similar problems the learner gains facility and confidence. Conceptual leaps commonly take place in learning higher mathematics. Most students of calculus can attest that, if one continues working with Delta-Epsilon proofs (suspending disbelief), one eventually comprehends it, and once mastered, the difficulty is forever gone. What is not so easy for the accomplished math teacher is to recognize that similar leaps occur in basic mathematics. Not recognizing, and therefore not discussing that part of the difficulty students have in grasping elemental relationships may be due to real gaps in the subject matter itself, instructors often reinforce students' feelings of inadequacy which contribute to the development of negative feelings toward math.

Mathematics is a cummulative subject: failure to master one concept or operation will continue to plague the learner. Math's cumulative nature, which significantly differentiates it from many other subjects, needs to be

pointed out to students. Unfortunately, students often learn only part of this message and quickly offer it as an excuse at every available opportunity: all experienced teachers are familiar with the student who was home sick the day fractions were taught.

The fact that there is an answer to nearly all mathematical problems can be comforting or disquieting, depending on one's orientation or learning style. For those who enjoy math and feel competent doing it, the knowledge that there is a correct answer is a plus and tends to reaffirm their belief that math is fair, objective, and goal-oriented. For many other equally intelligent and capable people, however, the need to arrive at the one correct answer leads them to perceive mathematics as authoritarian, rigid, and non-creative. Mathematical problem-solving to these people is a search for a predetermined answer that--although it may be already known by others--is being denied to or hidden from them. For these people, the instructor's task should be to encourage alternative ways of obtaining the answer--an easy technique to encourage diversity and allow individuals to express themselves.

To many mathematicians there is an innate elegance or beauty in both the process and outcome of a mathematical problem. While instructors may be hard put to explain this quality to the nonbeliever, they should at least communicate their own feelings to students. Even if students don't agree or can't see it, they may come to better understand the instructor's interest and excitement about mathematics. Improved interaction between teacher and learner can come about through an acknowledgement of basic postures and assumptions.

Many of the attributes about math that make it so appealing are poorly understood and rarely discussed even by mathematicians. By including this topic, we sought to enable instructors to rediscover these qualities, and to encourage classroom discussions that would introduce students to the affective predispositions the teacher brings to this subject.

Computational and Other Specific Problem Areas

Enough has been written about math anxiety among college-age and adult populations to enable us to identify many of the mathematical concepts, topics, and computational areas in which most of the problems arise that hamper the further acquisition of skill and understanding. MART covered four specific problem areas: word problems, signed numbers, fractions, and introductory algebra. These are not only subject areas in which many students experience the most difficulty, but also those one must master to do well in the more advanced math courses and in many careers.[1]

For presenting each topic, the workshop leader(s) used diverse strategies that could be adapted to the college classroom--emphasizing techniques that, based on personal experience, were less anxiety-provoking than standard approaches. Participants also received sets of written explanations that incorporated both the information and techniques suggested. We reasoned that by demonstrating these techniques with sample problems, participants would immediately see the applicability to their situations.

Again, some of the sample problems used in the workshop were purposefully constructed to be difficult for even an experienced mathematician. This was done to reinforce two points. First, difficult problems insured that participants would have to work through the new procedures slowly so that the positive differences between them and standard procedures would be highlighted; in other words, a problem which was too basic and which could be solved too quickly would detract attention from the significance of the new method. Second, the sample problems served as another reminder, evoking in faculty many of the same feelings students experience when confronted with a complex and seemingly unsolvable problem

Word problems. Word problems give students more difficulty than perhaps any other single type of mathematical problem. Typically, students groan when asked to do them. It is not uncommon for them to panic and, even before

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[1] Kogelman and Warren, and Tobias state that math anxious people generally report one of these topics as being the initial stumbling block. Mind Over Math and Overcoming Math Anxiety, op. cit.

reading the problem, to decide they are not able to solve it. Many adults clearly recall such experiences and remember thinking that: "If a train is going from New York to Chicago and another train travels from Chicago to New York...I'm going to jump out of the way."

This misconception is that one should be able to look at a word problem, read it through, and (based on that quick reading) solve the problem. As in the Math Myths, the nature of mathematics is again misperceived as something one does quickly and correctly in one's head. An alternative approach to teaching people how to attack word problems is called the Direct Translation Method.[1] The approach calls for the student to read one statement and immediately translate it into arithmetic form. Using this method, when you read that the "second of three numbers is one less than the first", you stop reading, pick up a pencil and think: "1 less" translates to minus one, or -1. If the first number is N and the "second number is one less than the first number," the second number must be N-1. And you write the N-1 down on paper. The problem-solver proceeds in this way statement by statement until a relationship in the form of an equation is formulated. Only then would she/he proceed with the calculations that are necessary to solve the equation.

The Direct Translation Method is designed to help people solve word problems not only in a logical and orderly manner, but more importantly, in a way which enables them to experience a series of small, progressive gains. Using the Direct Translation Method, students are writing "math" long before they realize they are doing it. By being advised not to read the whole problem, but to read and translate phrase-by-phrase, the student is relieved of a sense of being overwhelmed by the whole problem all at once.

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[1] We are thankful to S. Kogelman, Director of Mind Over Math, for permission to adapt this procedure.

Only a few highlights of the Direct Translation Method are touched on here, but workshop participants reviewed the procedure in detail, working with four specially prepared problems; three appropriate for community college students; the fourth problem presumed difficult for the participants. As noted, we wanted to promote use of the Direct Translation Method by presenting participants with a problem they would find difficult to solve by traditional problem-solving methods; and, at the same time, to create a situation in which participants would be likely to experience reactions similar to those of their students.[1]

Fractions. Another area of tremendous concern for most students (and especially the math anxious) is fractions. People tend to be uncertain about what fractions mean actually and about the arithmetic manipulations used when working with them. Students persistently question why, for example, when multiplying fractions the result is smaller, when multiplication is supposed to mean "get bigger." The approach to fractions introduced during the MART workshop differs from more traditional methods in insisting that: teaching fractions, even the second time around, requires concrete visualization with the "pie" the preferred symbol, rather than a rectangle; and to convey the specific mathematical meaning of 5/7, it is more instructive to say aloud "five of those things called sevenths" than "five-sevenths"--until students grasp the concept that, in principle, 5/7 is the same as 1/2.

MART employed specific exercises and examples so participants could develop facility with this way of presenting factions. They also received a handout--Some Thoughts on Teaching...Fractions--which summarized the process.

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[1]For those interested, the problem was:

A motor boat travels upstream from a fixed point for one mile at which time the captain of the motor boat drops a toy boat into the water. The toy boat travels downstream with the current, while the motor boat continues upstream for 20 more minutes, turns around, and heads back to where it started. The toy boat and the motor boat arrive at the point the motor boat started from at the same time. Find the rate of the current.

(The answer is 1.5 miles per hour. Inquiries on the solution are invited, but only after a little struggle. Please try the Direct Translation Method.)

Introductory algebra and signed numbers were covered in a similar manner. Major areas of student difficulty were outlined, suggested remedies were presented, participants worked through problems using the new approaches, and handouts were distributed. New ways of "demystifying x", "goal-oriented problem solving", and "using intuition in dealing with signed numbers" were advanced.

General Pedagogical Strategies

The principle concern of Project MART was to provide math faculty and faculty in math-based career programs with specific information about math anxiety so that they could modify their behavior in the classroom. Once the foundation had been established, and some specific topics introduced, we wanted the group to explore some generic pedagogical strategies and classroom management techniques which might alleviate student anxiety. We were also interested in learning from participants those successful procedures that all effective teachers develop--generally on the basis of trial-and-error.

Identifying problem students. Although the MARS-A and other instruments (such as the Fennema-Shermen Mathematics Attitudes Scales)[1] can be used to identify math anxious students, instructors often need less time-consuming ways of assessing students in their classes. Part of the MART workshop program was devoted to a discussion of classroom manifestations of math anxiety. To promote discussion, project staff drew from the literature and from the experiences of people who express discomfort with math another handout entitled, "The Characteristics of Math Anxiety-Avoidance and of the Math Anxious-Avoider". Two excerpts from the handout are given below.

> "As a generalization, math avoiders are uncomfortable with or unclear about fractions, decimals, percentages, signs, algebra, and statistics--just those skills that are most useful in everyday life and basic to applied mathematics in occupational curricula.

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[1] Fennema-Sherman. Mathematics Attitudes Scales. American Psychological Association, 1200 17th St. N.W., Washington, D.C.

"When faced with a mathematical problem, the severely math anxious person is likely to experience the sensation of an 'iron curtain' coming down over his or her eyes. Other common physical symptoms include sweaty palms, headaches, and stomach aches. The most common symptom is being 'unable to think.'

"Lack of competency in math may, by extension, lead to feelings of incompetency in related areas (e.g., mechanical skills), and to a more generalized inability to follow instructions or to read charts and diagrams.

"Many math anxious people have a strong desire to overcome their handicap, often coupled with an equally strong feeling of hopelessness about succeeding...

"...Because math avoiders are fearful that others may find out how dumb/stupid they are, they generally do not ask just those questions that would help them most."

The second excerpt comes directly from Mind Over Math.[1]

"It is not uncommon for math anxious people to say to themselves:
Everybody knows what to do, except me.
I don't do math fast enough.
I'm sure I learned it, but I can't remember what to do.
I knew I couldn't do math.
I don't have a math mind.
I got the right answer but I did it the wrong way..."

"Math anxious people also believe it when others say to them:
You did it the wrong way.
You should know that.
You will never be able to do math.
It's obvious.
That's an easy problem.
All you have to do to learn math is to work hard..."

Do's and don'ts. Time in the workshop was also spent on specific classroom do's and don'ts that could be integrated without significantly modifying participants' individual teaching styles. On the general topic of problem-solving, for example:

Since math is usually learned in groups, individuals rarely have the opportunity to discuss how they arrived at solutions. Yet even an incorrect

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[1] Mind Over Math, op.cit.

final answer often has been preceeded by correct and inventive steps. An instructor can demonstrate and support the possibility of creativity in math and give anxious students an opportunity to view math from a less rigid and dogmatic perspective by discussing alternative ways to solve a particular problem.

Other classroom Do's and Don'ts related to problem solving include the following advice to participants:

"Write things down, covering all steps. This technique helps discourage the tendency of students to simply memorize rules and procedures.

"Make illustrative sketches and diagrams before discussing procedures.

"Say the steps aloud and tell students to do so themselves when they are studying or solving a problem.

"Use practical problems and real-life examples whenever possible.

"Complete every sample or problem discussed in class. Go over the problem completely, from beginning to end--including the final answer.

"De-emphasize mental arithmetic and calculations."

Since negative feelings toward math result in part from the accumulation of negative classroom experiences, instructors should exhibit confidence in students' ability. Some simple Do's and Don'ts to accomplish this include:

"Avoid singling anyone out. Always ask for volunteers. Do not call on students to work at the blackboard who are uncomfortable doing so.

"Encourage students to keep working at a problem by pointing out to them what is constructive about their attempted solutions. Discuss the difference between taking time out and giving up.

"Emphasize the multiplicity of ways to arrive at solutions to math problems. First, present examples based on intuition. Then begin to develop procedures.

"Avoid saying 'This is a <u>better</u> way to do it.' It is more helpful to say 'This is just another way to do it.'

"Try not to foster feelings of competition among members of the class, nor between students and timed activities. Math already has a built-in competition between the person solving the problem and the fact that there is a solution."

Math texts. Another workshop topic concerned the selection and use of textbooks--viewed from the perspective of both the student and the instructor. One of the difficulties math anxious individuals encounter relates to the way math material is structured and presented in standard texts. Students are rarely told that a math text is read differently than fiction or other textbooks. When students, believing they should be able to read and comprehend a chapter of a math book as quickly as they do chapters in other books, are unable to do so they assume the fault lies in their lack of ability. This, of course, reinforces any discomfort or self doubt already present. Similarly, students are rarely informed that reading a math text is not a self-contained act, that reference books will be needed in much the same way as dictionaries are necessary when reading English literature or a story in a foreign language. In addition to talking about the differences between math texts and other written material, MART participants also discussed other areas, such as homework, in which teacher expectations should be talked about openly and early in each semester. Their own students' expectations need to be examined by instructors. In many cases it may be just a matter of clearing up some misconceptions, which if ignored, may mean that students won't understand their obligations or their instructor's expectation. This may mean that they will fall back on their self-defeating assumptions which, in turn, will continue to hinder more productive activity.

To complement students' needs to better understand the nature of math texts, teachers also need to be more alert to how texts present material in ways that may heighten the reader's anxiety. The Project MART workshop included a discussion, summarized on a handout provided to all participants, of some "Questions to Ask When Evaluating a Text Book". The criteria for textbook selection included traditional concerns (such as, an appropriate sequencing

of topics, sufficient examples), but also focused on student perceptions. For example, participants were asked to question whether a text-under-review was:

> "Written clearly and in a tone more sympathetic than condescending?
>
> "Replete with a sufficient number of good examples that are neither sexist nor racist?
>
> "At a level students can understand?
>
> "Consistent in the use of notations and symbols?"

Tests. Perhaps no other aspect of math increases student anxiety as much as testing. Unlike other subjects where students feel that they will receive partial credit for a partially correct answer, in mathematics the "right" answer is presumed to be lurking in the background. Among the things discussed in the workshop were "Tips on Tests, Test Construction, and Class Preparation". The discussion centered around the implications of awarding or not awarding partial credit, timed versus untimed tests, make-up tests, surprise quizzes, tests' different purposes, and alternative item formats. Participants were encouraged to be open with students about testing: to tell their classes what material would be covered on a test, how answers would be scored, and the relative weight of test scores to the final grade.

These four topics--ways to identify the math avoider, basic do's and don'ts in classroom teaching, reading and evaluating math texts, and testing--were designed to illustrate how information about math anxiety can be translated into teaching strategies. The suggestions we made were specific to mathematics and math-related courses, but many of them are applicable to other subjects.

Future Plans

Many programs of inherent value frequently fail to be adopted after funded monies are exhausted. To overcome one of the realities common to most supported research and developmental acitivity, we attempted to institutionalize some of the program's components: approximately one-fourth of the workshop was devoted

to planning continuation activities. MART staff prepared a list of possible followup activities and participants were asked which ones they wanted to pursue. Based on their feedback, we prepared additional materials and involved other colleagues. The suggested activities included: establishing an ongoing student-centered math clinic; organizing inservice MART-like training for other faculty; training math tutors in math anxiety reduction skills; designing basic and applied research studies to complement existing research; and proposal writing-grantsmanship. We will return to a discussion of these activities in the next section.

Schedule of Topics

As we discussed at the beginning of the chapter, our choice of topics was based on assumptions we made about community college math instructors and students. In deciding the sequence in which these topics would be presented, we were guided by the program's objectives, our past experiences, and the presumed interests of the participants.

We felt, for example, that participants would welcome a systematic presentation which began with an understanding of the background, rationale, and previous work in math anxiety, math and careers, and sex differences in mathematics, followed by work with very specific mathematical concepts and computations in a classroom setting. Moving from the global to the specific seemed to the program staff to be the most effective and efficient approach. We believed that the participants, given some time, would more readily accept and act on specific suggestions and act on recommendations if a theoretical foundation was firmly established.

In practice, a number of sequence modifications occurred. The first were made in order to vary the pace of the program and enhance audience participation. Even in dealing with topics that favored a didactic approach, we incorporated ways of involving participants. A script and all materials were prepared in advance to enable us to defer a topic, or move one forward to build on what was happening moment-by-moment within a session. These precautions were justified. By the end of the first Tuesday session, it was apparent that parti-

cipants were more interested in discussing specific teaching strategies and in learning ways to respond to their students than they were in theoretical issues. This is not to imply that the participants were disinterested in the research or other work being done, for they continued to question the underlying rationale throughout the course of the program, but it was very clear that they preferred dealing with more directly practical applications. As a result, the order of topics was changed, more "math" was introduced at early sessions, and certain topics were eliminated or de-emphasized. Figure 1, page 14, summarizes the final sequence of topics for the first workshop cycle. Word problems, originally planned for the fourth session, was moved to the second session, and the comprehensive review of the literature was played down partly because of time restrictions and partly because many people did not seem interested.[1]

We also eliminated, as discrete topics, "Do's and Don'ts in Classroom Teaching" and "What is Math?" "Do's and Don'ts" was initially conceived as an introduction to general teaching strategies. "What is Math?" was planned as a way of helping participants begin to understand that others do not readily accept as positive the qualities of math that make this subject enjoyable to them. Both topics were addressed in the program, but in a non-structured way.

The concluding sessions, which dealt with "Future Plans" were intentionally left open. The Tuesday group was interested in how they might expand or modify their existing tutorial program to address math anxiety/avoidance issues, and in how to obtain funds for this and related purposes.

To capitalize on their interests and thereby help pave the way for follow-up activity on their campus, project staff devoted one workshop session to the distinctions between tutorial and math anxiety programs, and between remediation and counseling. To assist participants in grant writing skills in the final session, we introduced two exercises, supplied them with extensive suggestions for sources of funding, practiced proposal writing (style and content),and

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[1] Instead, we distributed "Additional Readings" which annotated much of the literature on math anxiety/avoidance and served as a guide for those who wanted to pursue this topic in greater depth.

involved the college's grants officer and other college administrators with whom most of the group were not familiar.

Since the second series did not begin until the end of the first cycle, more changes in the Saturday agenda were possible. As can be seen in Figure 2 (page 15), the Saturday schedule introduced fractions, word problems, signed numbers, and algebra earlier, and in each of the four sessions some time was spent on one of these topics.

"What is Math?" and much of the math anxiety/avoidance background information were retained as separate topics for the Saturday group. Despite the lack of interest on the part of the first cycle participants, we still believed that a more complete understanding of these issues would foster modifications in instructional behavior; and that part of the problem lay in the composition of the first group rather than in the material itself. The Saturday participants reacted positively to their inclusion.

Again, because of time restraints other topics were abbreviated but in most cases, the sequence was similar for both groups. The videotape was used in Session 3 of the second cycle, instead of in Session 2 as an introduction to the discussion of the characteristics of the math anxious/math avoiding student, because of a problem with the delivery of the playback equipment.

Participants in the second cycle chose ways of disseminating Project MART results as their preferred follow-up activity, although they were also interested in funded research and demonstration proposals. Since they came from different colleges and universities they were much more concerned with what they should do on their own campuses and within their own departments to increase and involve others: almost the entire final session was spent discussing specific steps they could take on their own or as part of a small group to improve their own competencies and to serve as models for colleagues who were either unacquainted or reluctant to deal with math anxiety.

What the agenda descriptions do not convey are the various ways in which the content was presented. These appear in the leader's script and include

an interplay of lecture, role-playing, simulation exercises, and demonstrations by the math consultant and by participant volunteers. Our efforts to keep the atmosphere collegial were, to a large extent, successful.

All project staff played an active role in the sessions, with senior staff frequently co-leading them. The use of an expert mathematician is crucial in any field replication. Though competent educators could fulfill these responsibilities, the credibility of a staff development effort depends largely on the credibility of the leader-teacher. Staff can be used in several supplementary ways: as reactors, as reinforcers, as observers, and as colleagues-in-training.

CHAPTER IV

MART: IMPACT AND PARTICIPANTS' REACTIONS

Staff development projects typically seek to provide new information to or promote new attitudes among a specified population. Such projects, directed to teachers, usually receive mixed reviews. Project MART is no exception. Instructional staff, though receptive to new ideas, tend to be somewhat more conservative in adopting them than are other types of workers. Teaching--especially at the college level--is by its very nature an isolated and private activity, with little collegial review or observation and little opportunity to discuss or question individual personal practices. Unlike teachers at the elementary and secondary level, college instructors usually have had little training in "methods," and few belong to professional organizations or subscribe to pedagogically-oriented journals. They tend to model their own behavior on that of their instructors and to base their expectations of student performance on their own experiences as learners.

Two data collection techniques were used to assess MART's impact: observation (all staff attending any MART session were required to take detailed notes) and questionnaires for participants. The MARS-A, discussed in Chapter III, was not intended to measure either outcome or change, but to document the extent of math anxiety among community college students. The results reported in this chapter are based exclusively on observation and participants' questionnaire responses.

General Observations

Overall, the MART participants were initially reluctant--some were resistant--to deal with student math anxiety. At the beginning, this reluctance was manifested in questions about why we were directing our efforts to the in-class behavior and presentations of math faculty instead of toward work with counselors, calling on math faculty as resources. By the end of the workshop series, although there was increased acceptance of the project's basic premises, first-cycle participants in particular were still seeking ways to deal with the problem

outside the classroom setting--in their case, through a redesign of their student tutor-based math laboratory.

From the outset, the Tuesday group was difficult to involve and interest. Although we were prepared for some initial skepticism and some reserve, we expected less formality and more active involvement as time went on. Tuesday participants, however, remained quite formal (raising their hands to ask a question or to comment, addressing each other and project staff by titles and last names, and responding only to direct questions.)

The second series started out similarly, but by the first lunch break the participants had relaxed and the atmosphere had become warm and supportive. It would not be accurate to claim that this group accepted everything we presented, but they were willing to investigate the issues. One illustration of the differences between the two groups was in the way they treated one another. Each group included a "ham" among its members--an outspoken participant who often made irrelevant (and irreverant) remarks. His comments were ignored by the Tuesday group who busied themselves with their papers or used the occasion to engage a neighbor in conversation. In contrast, the Saturday group responded to him lightly--firmly demanding that he not interrupt, but always in a kindly way. Another example concerned refreshments: on Tuesdays, coffee and cake were served. The participants were polite and appreciative, but irritated if refreshments weren't set up when they arrived. And, at the conclusion of the sessions no one helped with the housekeeping. On Saturdays, when project staff provided lunch as well as morning coffee, one participant baked bread for the group; another brought a cake to a session; one set up the A-V equipment; many helped clean up and kept us company after the sessions.

Obviously, the two groups were not the same to begin with. First-cycle participants were all from the same college but from two departments with differing philosophies. They were and will continue to be co-workers. Probably because of the high-level administrative support MART had at that college, starting with the President, the two chairpeople attended as participants and theirpresence probably had an inhibiting effect on the group.

Furthermore, since the program was conducted at their worksite, and although we led the group and fed them, we were clearly visitors. One concensus was that this group, for whatever set of reasons, may have perceived themselves as a unit protecting their school turf and us as outsiders with an agenda for change and thus felt a need to react defensively.

The second-cycle group, on the other hand, was composed of faculty from a number of different colleges. The workshop was held on neutral ground, where we were obviously hosts. They, as guests, dressed comfortably, came expecting to have a good time, and to gain something for having given up leisure time. Interestingly, we met in a classroom with lecture-style seating; The Tuesday group sat around a large table in the President's lounge.

There were other differences between groups. On the average, the Tuesday participants were older, had more college teaching experience, and were predominantly male--the majority of whom taught in the regular mathematics department. The Saturday participants were more evenly divided between females and males, were younger, had an average of three to four years less teaching experience, had more diverse academic training,and were working in a wider variety of settings.

One of the interesting behavioral patterns that we noted in both groups was their tendency to do many of the same things they cannot tolerate their students doing: holding private conversations, arriving late, forgetting to bring what they need with them, losing or misplacing papers, and so on. When presented with a purposefully difficult problem, they complained (as do their students) that they "weren't given enough information" or that "it's a trick question."

In general, the participants were polite and, in some instances, deferential to the workshop leader. Disagreement was normally confined to telling him that "our students are not like that." Indeed, even after the Tuesday group was shown the videotape (which was an accurate portrayal of high school seniors on route to that community college) they still refused to acknowledge that we understood their students. "Our students are different" was the rationale for rejecting suggestions and innovations.

Most of the written MART materials (handouts) were well-received, and participants who had been absent or who arrived late wanted to be sure they had copies of what had been distributed. As time went on, people in both groups brought us articles and books they thought we would be interested in, and became increasingly more willing to share with us and their colleagues some of the things they had tried in class. As time went on, more and more people came to the board to demonstrate their own techniques--even those they considered to have failed in the classroom.

Almost without exception, any math problem that tested their skill stimulated intense activity. The toy boat problem was especially indicative. Some gave up almost immediately, although others continued to work on the solution, engaging in subtle competition to see who could arrive at the correct answer first; how the problem was solved was a secondary concern. To the degree that this experience produced in participants the reactions of frustration and hopelessness that are commonplace for math anxious students, the exercise was a success.

Much of the content of the MART series, however, seemed of little interest; the more theoretical, the more removed from practical application, the less interested they appeared. Nor were they particularly impressed with some of the alternate teaching strategies presented. Some of our approaches, which indeed are similar to those used in teaching math several decades ago and which have been proven to be effective instructional strategies, participants rejected as being "babyish", "condescending", or "outmoded."

Two general themes were particularly difficult for participants to deal with: student achievement level, and grading and testing. Many community college students perform considerably below grade level. The MART viewpoint was that re-teaching basic arithmetic and algebraic manipulations would help speed up subsequent learning. The participants, however, were loathe to accept this responsibility, arguing that students should have learned these concepts earlier and that in any case, the constraints of their syllabus did not allow them time to review these topics thoroughly.

Perhaps the most heated discussions concerned grading and testing. In our experiences with students, questions of partial credit, make-up exams, and surprise quizzes always provoke strong sentiments. We now know they arouse equal passion among faculty. (It was not our intention in raising these issues to change anyone's opinion or to seek a consensus, but rather to explore the MART position that grading and testing can be made part of the learning experience and that the instructor's policies should reflect his/her goals and be clearly explained to students at the beginning of each semester. In general, however, many participants again questioned this as their responsibility.) On the issue of partial credit, participants' opinion ranged from absolute rejection ("there is no partial credit in the 'real world' ") to insistence on its absolute importance ("people should receive credit for what they have in fact accomplished").

Participants' feelings about testing were equally varied. At one extreme, one participant said "I have been giving the same test for 20 years, and if no one passes it's not my fault." On the other hand, many viewed tests as a measure of the instructor's competence. Discussions of grading and testing permitted the groups to integrate the implications stemming from belief in the math myths, the importance of examining teaching from the students' perspective, and the characteristics of mathematical solutions that they reward with high grades.

A generalized reluctance to reconsider their own effectiveness and communication from the viewpoint of the student persisted throughout the program. Yet by the conclusion of the series both Tuesday and Saturday groups seemed to have moved toward a more responsive position. Without examining the pre- and postprogram survey data, we would be uncertain whether participation in the MART program had affected faculty attitudes, and if so whether change had been in the desired direction. Based on observation alone, we would have concluded that the program's major achievement was to expose participants to a variety of new points of view, general theories of learning, and methods of teaching.

Pre- and Postprogram Attitude Changes

The Faculty Followup Survey of MART participants repeated several questions from the initial Faculty Opionion Survey;[1] for these questions we are able to examine pre- to postprogram changes. (Demographic items were included only once on one or the other version of the Survey.) Although statistical tests (t-tests) were made of the significance of the mean changes, too much credence should not be given to them for serveral reasons: the questions were all attitudinal, the time interval between the two administrations was relatively brief (first cycle, 10 weeks; second cycle, 4 weeks), and the number of subjects was small.[2] Given these circumstances, large changes would not be expected, and in fact did not occur. However, it is of interest to look at the direction of change in relation to the content of the program.

General attitudes toward math. The first set of items dealt with some general attitudes toward mathematics and math instruction; several math myths were included. Respondents were asked to indicate the degree of their disagreement or agreement with each of 13 statements. Table 1 presents the mean differences for each of the two groups and the significance of the differences, if any; a plus (+) sign denotes greater agreement on the post- than on the pretest, and a minus (-) sign denotes a shift toward greater disagreement by the end of the program.

For some of these items, we could and did decide that there is a "desirable" direction of change. The desirable shift on items #1, 2, and 5 is toward greater agreement (a positive difference); and on items #3, 4, and 6 to 8 toward greater disagreement (a negative difference).[3] Before looking

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[1] Copies of these instruments are appended; see Appendix C.

[2] All pre-post comparisons were based on respondents who were present for both tests: first cycle = 12; second cycle = 13.

[3] Items #12 and 13 are ambiguously worded--although there was an expectation that attitudes should be more positive; and for items #9, 10, and 11, the desired direction is indeterminate.

TABLE 1

GENERAL FEELINGS ABOUT MATH: MEAN DIFFERENCES (POSTTEST-PRETEST)[a] IN HOW STRONGLY PARTICIPANTS AGREE OR DISAGREE WITH 13 STATEMENTS

(Expected Direction Of Change)	#	STATEMENTS	Group: Tuesday (N=12)	Group: Saturday (N=13)
+	1.	Instructors should tell students the difficulties they themselves have in math.	+.50	+.15
+	2.	A good mathematical solution is elegant.	+.33	+.33
-	3.	Generally there is only one good way to solve a math problem.	+.33	-.08
-	4.	Math is a subject that one either knows or doesn't know.	0	0
+	5.	Calculators should not be used in class.	+.18	+.33*
-	6.	Elementary school pupils should be discouraged from counting on their fingers.	-.64*	-.17
-	7.	Math is not creative.	-.08	+.23
-	8.	Some people have a "math mind" and some don't.	-.42	-.08
?	9.	Math is nice because it permits one to evaluate his/her own accomplishments.	+.91**	+.20
?	10.	Math is neat and tidy.	+.33	-.23
?	11.	It doesn't matter how they do it as long as students get the right answers.	-.08	+.23
ambiguous	12.	It is important to present single, clear, unambiguous solutions to math problems.	-.09	+.25
ambiguous	13.	Students should keep working on a problem until they find the solution.	+.18	-.15

[a] a(+)positive difference indicates greater agreement
a(-)negative difference indicates greater disagreement

NOTE:
** = significant at the .01 level
* = significant at the .05 level
△ = approaches significance (.10 level of confidence)

at the results, it is important to keep in mind that the amount of change possible is limited by the level of the initial scores; if, for example, the participants initially disagreed fairly strongly with a statement, then there would be little room to shift toward greater disagreement on the posttest.

On the first two items, both the first cycle and the second cycle groups shifted in the expected direction. On the pretest they tended toward agreeing that teachers should tell students about their own difficulties in math, and that "a good mathematical solution is elegant." By the posttest, their agreement was even stronger. During the workshop participants offered little resistance to these topics. On one other item (#5) where we would expect a shift toward agreement, was the change in accord with expectation; both groups shifted toward greater agreement that "calculators should not be used in class." Although the use of calculators was rarely mentioned, MART discussions did emphasize the importance of practice in developing arithmetic and mathematical skill. In spite of this shift, however, the posttest means are still on the side of disagreeing with this statement, and very strongly so in the Saturday group.

Participants tended to disagree initially, and in some cases quite strongly, with most of the next six items (#3-8) on the table. It is not surprising, then, that the change on these items was relatively small. As the workshop discussions led us to expect, both groups disagreed more strongly on the posttest that "some people have a 'math mind' and some do not"; and both groups felt less inclined to discourage young pupils from counting on their fingers--the Tuesday participants significantly so. (Note that on these two items the initial mean scores allowed for more possibility of a shift toward increased disagreement than, for example, did item #4.) On this latter item (#4), neither group changed at all from their early strong disagreement that "math is a subject that one either knows or doesn't know."

On four of the remaining five items, the two groups shifted in opposite directions, although the magnitude of these changes was slight. The only exception is item #9, "Math is nice because it permits one to evaluate

his/her own accomplishments." Initially both groups tended to agree with this statement, and to about the same extent. By the posttest, their agreement increased--markedly so for the Tuesday group which had devoted more time to talking about the reasons they found math personally satisfying. In other words, MART may have helped the participants recapture their feelings that "math is nice."

Being an effective math teacher. Faculty rated 11 items in terms of their importance to being an effective teacher of mathematics. Mean differences (posttest minus pretest scores) for the two groups are shown in Table 2. A positive difference denotes an increase in the degree of importance attributed to the item. The desired change was that these items--that is, the differences--would be positive, would become more important.

As was true for the preceeding set of statements, here too the changes were generally quite small. On four items both groups showed the expected positive shifts: as factors in effective math teaching, by the end of the program they attributed greater importance to a knowledge of math history, math folklore, and mathematical research issues, and to membership in professional organizations. Both groups attributed less importance to being skillful at arithmetic calculations on the posttest. Again, the desired changes may also reflect MART's effectiveness in stimulating participants to take a fresh look at their professional identity.

Interestingly, as can be seen in Table 2, first-cycle participant attitudes changed in the desired direction on seven of the 11 items; second-cycle participants on five items, four of which overlapped the first group. But in each instance these results are an artifact: the Saturday group initially rated these items almost as high as the scale permits, and thus had no room for movement. What is more compelling, is the shift in the attitudes of the Tuesday (first cycle) participants. (See Table 2, page 50 .)

Solving difficult math problems. Ratings of importance were also obtained for eight factors that may contribute to the solution of difficult

TABLE 2

BEING AN EFFECTIVE MATH TEACHER: MEAN DIFFERENCES (POSTTEST-PRETEST)[a] IN PARTICIPANTS' RATINGS OF THE IMPORTANCE OF 11 FACTORS

Direction of Desired Change	FACTORS	GROUPS		ALL RESPONDENTS (N=25)
		Tuesday (N=12)	Saturday (N=13)	
+	Knowledge of math history	+.17	+.42	+.29
+	Knowledge of math folklore	+.08	+.42	+.25
?	Skill at arithmetic calculations	-.33*	-.50**	-.42
+	Pedagogical technique	+.25∠	-.08	+.08
+	Knowledge of the psychology of learning	+.17	-.27	-.04
+	Preference for the specific subject	-.08	-.17	-.12
?	Competence in the specific subject	0	-.33	-.17
+	Knowledge of mathematical research issues	+.25∠	+.33	+.29
+	Membership in professional organizations and associations	+.33*	+.33	+.33
+	Knowledge of students' feelings	-.08	+.08	0
+	Knowledge of how math relates to other subject areas	+.17	-.08	+.04

[a] a(+) positive difference = greater agreement or importance from pretest to posttest
a(-) negative difference = lesser agreement or importance from pretest to posttest

NOTE:

** = significant at the .01 level
* = significant at the .05 level
∠ = approaches significance (.10 level of confidence)

math problems. Here again we expected the responses to shift toward attributing greater importance to each of the items. Table 3 below presents the mean differences (post- minus pretest) for the two groups of participants.

TABLE 3

SOLVING DIFFICULT MATH PROBLEMS: MEAN DIFFERENCES (POSTTEST-PRETEST)[a] IN PARTICIPANTS' RATINGS OF THE IMPORTANCE OF 8 FACTORS

Direction of Desired Change	FACTORS	GROUPS		ALL RESPONDENTS (N=25)
		Tuesday (N=12)	Saturday (N=13)	
+	Ability to do arithmetic calculations	-.25*	+.25	0
+	Knowing basic mathematical concepts	-.08	+.08	0
+	Knowing how others did the problem	+.42*	-.42 △	0
+	Knowing what has failed in previous attempted solutions	+.42*	-.25	+.08
+	Logic	-.08	-.33*	-.21
+	Intuition or guessing	+.50**	-.08	+.21
+	Perseverance	0	-.33	-.17
+	Practicing similar, but easier problems	+.17	+.08	+.12

[a] a(+) positive difference = greater agreement or importance from pretest to posttest
a(-) negative difference = lesser agreement or importance from pretest to posttest

NOTE:

** = significant at the .01 level
* = significant at the .05 level
△ = approaches significance (.10 level of confidence)

On only one item did both groups shift in the desired direction--both considered "practicing similar but easier problems" slightly more important on the posttest. On several other of the seven remaining factors, both groups showed about equal but opposite amounts of change on the posttest. The first-cycle group attributed more importance to "knowing how others did the problem", to "knowing what failed in previous attempted solutions". and to "intuition or guessing"; they considered it less important than they did initially to be able to "do arithmetic calculations." The Saturday group, however, rated this latter item as being more important, but gave lowered importance ratings to knowing how others did the problem, to what failed in past attempts, as well as to logic and to perserverance.

In all, neither group's ratings of these factors were in accord with the program's intent or with the staffs'observations: MART stressed the role of intuition and perserverance in the solution of difficult problems, the benefit of practice with similar problems, and an appreciation of the attempts of others. Our impression was that the Saturday group was more influenced by discussion of these and related factors, but since the initial scores of both groups tended to be similar on this set of questions, the contradictory findings may represent real, though non-observed changes.

Assigning course grades. The next set of items dealt with the importance of 10 factors that may be involved in deciding a student's grade. Here we made no predictions about the expected, desired direction of change. The mean posttest minus pretest differences for the first- and second-cycle groups are shown in Table 4, page 53 .

On the posttest both groups assigned greater importance, as a determinant of a student's grade, to the teacher's own general impression, the student's general attitude in class, and the effort the student makes. Both groups attributed less importance (even if only slightly so) to participation in class and to performance on the final and midterm exams. Neither group changed their views about the importance of quizzes. On the three remaining items, the direction of change differed between the two groups. The Tuesday

TABLE 4

COMPUTING A STUDENT'S GRADE: MEAN DIFFERENCES (POSTTEST-PRETEST)[a] IN THE IMPORTANCE OF 10 FACTORS

FACTORS	GROUPS		ALL RESPONDENTS (N=25)
	Tuesday (N=12)	Saturday (N=13)	
Performance on the final	-.17	-.08	-.12
Performance on the mid-term	-.10	-.08	-.08
Performance on quizzes	0	0	0
Participation in class	-.33*	-.08	-.17
Completion of homework	-.25 ∧	+.33	+.04
Student's general ability level	+.20	-.09	+.05
The effort the student makes	+.17	+.23	+.20
The student's general attitude in class	+.50*	+.33*	+.42
Your general impression	+.55**	+.42 ∴	+.48
Departmental policy	+.20	-.33*	-.03

[a] a(+) positive difference = greater agreement or importance from pretest to posttest
a(-) negative difference = lesser agreement or importance from pretest to posttest

NOTE:
** = significant at the .01 level
* = significant at the .05 level
∴ = approaches significance (.10 level of confidence)

group viewed completion of homework less important than they did initially, while it became more important to the Saturday group. The Tuesday group assigned more importance to the student's general ability level and to departmental policy; the Saturday group attributed less importance to both as determinants of a student's grade. The difference in the groups' attitude toward this latter item may be attributed to the presence of the two department chairpeople.

Partial credit. The final series of repeated questions consisted of two algebraic problems (A and B) with three incorrect solutions presented for each problem. The respondent was to grade each solution by assigning it a score between 0 (no credit) and 10 (full credit). The first solution to Problem A represented a trial-and-error approach that involved no algebraic manipulation. The other two incorrect solutions represent, respectively, carelessness and a transpositional error that nevertheless showed some understanding of algebra. In Problem B, the first solution contained multiple errors that could be attributed to carelessness, anxiety, or a lack of understanding of how to handle equations involving fractions. The second incorrect solution had two sloppy errors. The third involved one obviously careless mistake (involving a sign) in an otherwise knowledgeable solution.[1]

Participants spent a great amount of time during the workshop discussing partial credit for incorrect answers. In general, they seemed averse to this practice. In terms of initial scores, then, we would expect very few instances of partial credit; in terms of change, let's look at the results shown in Table 5, page 55.

The Tuesday group, which initially gave no or very little credit (less than 1 point) to the first solution of Problem A, awarded it significantly more credit on the posttest--an indication that they had become willing to view both partial credit and an alternative (i.e., non-algebraic) solution in a more favorable light. They gave 5+ credits initially to the other two incorrect solutions to Problem A, and on the posttest gave each solution slightly more. The second-cycle group also gave the least credit to the first Problem A solution initially (although they awarded it many more points that did the first group) but changed direction on the posttest. There was no change in the number of credits the Saturday group assigned to the second

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[1] See the appended copies of the Survey(s).

TABLE 5

AWARDING PARTIAL CREDIT: MEAN DIFFERENCES (POSTTEST-PRETEST)[a] IN PARTICIPANTS' ASSIGNING CREDIT TO EACH OF 3 INCORRECT SOLUTIONS TO 2 PROBLEMS

ALGEBRAIC PROBLEMS	Tuesday Cycle (N=12)	Saturday Cycle (N=13)	All Respondents (N=25)
Problem A:			
Solution #1	+.67*	-.18	+.26
#2	+.08	0	+.04
#3	+.08	+.91△	+.48
Problem B:			
Solution #1	+.08	+1.36△	+.70
#2	+.08	+.64	+.35
#3	-.42	-.09	-.26

[a] a(+) positive difference = more credit (on a scale of 0 - 10) given on the posttest
a(-) negative difference = less credit given on the posttest than on the pretest

NOTE:
** = significant at the .01 level
* = significant at the .05 level
△ = approaches significance (.10 level of confidence)

solution, but a large increase in points awarded to solution #3. With respect to Problem A, then, the Tuesday participants seemed to be more amenable to assigning partial credit at the posttest than when they had started the program.

Both groups changed in the same direction in scoring the three solutions to Problem B. For each solution, the Saturday group's initial and posttest scores were higher than those of the Tuesday group (i.e., they assigned more credit--they were more lenient.) Overall, by the end of the program both

groups tended to be more willing to assign more credit for incorrect responses--with the possible exception of the one obvious careless error in the handling of a sign in what was otherwise a correct and knowledgeable solution (Solution #3, Problem B).

Participants' Assessment of Project MART

The Faculty Followup Survey (posttest) contained three sets of questions (#7, #8, #9) pertaining to MART's helpfulness, the usefulness of the MART written materials, and to an overall assessment. For these questions we used the responses of all participants, including those who had not completed the pretest Survey.

MART's helpfulness. Using a 4-point scale, participants were asked to rate how helpful MART had been in stimulating their understanding or consideration of 13 topics. These ratings are summarized in Table 6: the higher the score, the more helpful was the program judged to be.

Each of the 13 statements was rated higher (i.e., MART was more helpful) by the Saturday participants who found MART most effective in helping them "understand the needs of the math anxious student", followed by "how to identify the math anxious student". Also rated highly (above "somewhat helpful"), was understanding "your students' reactions to you", "your teaching techniques" and "how much you, as a mathematician, take for granted." MART was judged relatively least helpful in "your grading criteria." The Tuesday group rated these statements much the same: MART was, for them, (in contradiction to how they scored Problems A and B) least helpful in terms of their "grading criteria" and most helpful in increasing their understanding of "how to identify the math anxious student" and "understanding the needs of the math anxious student." They also found the program relatively helpful in terms of their teaching techniques and in how much they take for granted as mathematicians.

TABLE 6

PARTICIPANTS' MEAN RATINGS OF MART'S HELPFULNESS
IN STIMULATING UNDERSTANDING OR CONSIDERATION OF 13 TOPICS

TOPICS	GROUPS		ALL RESPONDENTS (N=26)
	Tuesday (N=13)	Saturday (N=13)	
the needs of the math anxious student	3.23[a]	3.62	3.42
your grading criteria	2.15	2.67	2.40
your testing strategy	2.38	3.08	2.73
your teaching techniques	2.85	3.38	3.12
your students' reactions to you	2.77	3.46	3.12
your expectations for your students	2.62	2.85	2.84
how to identify the math anxious student	3.31	3.46	3.38
your understanding of how much your students know	2.46	2.62	2.54
the way you teach fractions	2.54	3.09	2.79
the way you teach algebra	2.62	3.33	2.75
the way you teach word problems	2.46	3.41	2.52
the way you teach signed numbers	2.31	2.70	2.48
how much you as a mathematician take for granted	2.85	3.17	3.00

[a] 1.0 = not at all helpful, 2.0 = not very helpful, 3.0 = somewhat helpful, 4.0 = very helpful. The higher the score, the more helpful the program.

Written materials. Nineteen pieces of written materials, including some problem exercises, were rated by participants for usefulness. These data are shown in Table 7. As with the preceeding question, the higher the score the more useful the material was judged to be. (See Table 7, page 58.)

Again, the Saturday cycle rated the materials more useful than did the Tuesday group, with the exception of "the research article summarizing sex differences and other affective variables." The Saturday group found the three most useful pieces to be (in decreasing order) the book Mind Over Math, "Tips on Tests, Testing, and Class Preparation," and the "Direct Translation Method." The least useful materials (rated between "not very" and "somewhat" useful) were the research article and the cartoons.

TABLE 7

PARTICIPANTS' MEAN RATINGS OF THE USEFULNESS OF MART WRITTEN MATERIALS

WRITTEN MATERIALS	GROUPS		ALL RESPONDENTS (N=26)
	Tuesday (N=13)	Saturday (N=13)	
The research article summarizing sex differences and other affective variables	2.85[a]	2.67	2.77
The collection of cartoons and the discussion of how mathematicians are perceived	2.46	2.55	2.50
Characteristics of the Math Anxious Student	3.38	3.50	3.44
The Bibliography summarizing selected research on math anxiety	3.00	3.40	3.19
Math Myths and Their Implications	2.85	3.08	3.67
The direct translation method for approaching word problems	2.38	3.54	2.96
The "toy boat" problem	2.25	3.50	2.88
The chauvinistic movie ticket problem	2.45	3.00	2.50
Kogelman and Warren's Mind Over Math	2.75	3.60	3.14
The MARS-A (student rating scale) and results	2.73	3.38	3.00
The description of the Fennema-Sherman Math Test	2.60	3.00	2.78
Thoughts on Teaching Fractions	2.54	3.09	2.79
Tips on Tests, Testing, & Class Preparation	2.67	3.56	3.05
Thoughts on Teaching Algebra	2.55	3.22	2.85
Thoughts on Teaching Sign Numbers	2.36	3.25	2.74
Grading	2.42	3.33	2.81
How to Read Math Books	2.67	3.38	2.95
Evaluating Math Texts	2.40	3.38	2.83
Do's and Dont's in the Classroom	2.92	3.50	3.15

[a] 1.0 = not at all useful; 2.0 = not very useful; 3.0 = somewhat useful; 4.0 = very useful. The higher the score, the more useful the piece of material.

NOTE: Means based on responses of participants who said they had read the materials.

For the Tuesday group, the most useful material was a summary of the "Characteristics of the Math Anxious Student" and the "Research Bibliography." Everything else was rated between "not very" and "somewhat" useful. Least useful to this group of people was the toy boat problem (rated highly by the Saturday cycle), "Signed Numbers" (also rated highly by the Saturday group), the "Direct Translation Method", and "Evaluating Math Texts".

In general, the two groups were very different with respect to their reactions to the materials--with the Tuesday group tending to prefer the more academic material that related more closely to math anxious students.

Overall reactions to the program. The final question asked the respondents to compare MART to other staff development programs they participated in or heard about, in terms of its worth, relevance, interest, provocativeness, planning, and organization. Table 8, page 60, shows the ratings of the first and second cycle participants. Once again, the higher the score the better the program was rated.

As has been the pattern, people who participated in the Saturday cycle rated the program higher on every dimension than did the Tuesday participants; on each and every scale, MART was rated better than "somewhat". The highest rating MART received was for being "thought provoking." The Tuesday group gave the highest rating to MART's organization (rated relatively least well

To a surprising extent, the Survey findings do not alwasy support the project staffs' observations. Our impressions of the greater enthusiasm, interest, and involvement of the Saturday participants is confirmed: overall, they rated the experience better, the materials more useful, and judged that the program was very helpful in terms of increasing their understanding and in stimulating them to consider themselves and their students in different ways. What was unexpected was not the more reserved, conservative judgments of the people who attended the Tuesday workshop series, but the relatively great amount of attitudinal change they exhibited--and in the desired direction.

TABLE 8

PARTICIPANTS' MEAN OVERALL RATINGS
OF PROJECT MART ON 6 DIMENSIONS

DIMENSIONS	GROUPS		ALL RESPONDENTS (N=26)
	Tuesday (N=13)	Saturday (N=13)	
Worthwhile	2.92[a]	3.77	3.35
Relevant	3.15	3.77	3.46
Interesting	3.15	3.67	3.40
Thought provoking	3.38	3.85	3.62
Well planned	3.38	3.77	3.58
Well organized	3.46	3.62	3.54

[a]For each dimension, the following scale was used: 1.0 = Not At All, 2.0 = Not Very, 3.0 = Somewhat, and 4.0 = Very. The higher the score, the more positive the rating.

Attempting to integrate our observations and the assessed changes in attitudes leads us to conclude that we may have been deceptively influenced by the low-keyed nature of what occured on Tuesday. In other words, it is apparent that the first-cycle participants were more receptive to our ideas than their overt behavior indicated; we suspect, therefore, that their seeming indifference and challenging was stylistic (and more typical of academics), perhaps reinforced by the presence of the department chairpeople and some older members of the department.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

During the 1979-80 academic year, with a grant from the New York State Education Department, the CASE Institute for Research and Development in Occupational Education (IRDOE) undertook a staff development workshop program. Project MART (Mathematics Anxiety Reduction Training) was designed for math faculty and other faculty who teach math-based subjects to community college students. Reflecting a position that inadequate skill in mathematics (resulting from attitudinal and/or experiential factors) limits college students' occupational options, MART sought new ways to upgrade students' performance.

The recent attention being paid to math anxiety/math avoidance as a major obstacle to learning mathematics suggested that we explore these phenomena within the CUNY community college system: a review of the literature indicated that most of what is known about math anxiety is based on the experiences of high achieving students--predominantly female--attending prestigious private four-year colleges and universities who actively seek out help for their problems in mathematics. These otherwise capable, competent people (who have fairly severe difficulty dealing with mathematics in school and/or at work) are the populations served by the new math clinics and groups usually run jointly by mathematicians and counselors. If math anxiety comprises a continuum of negative reactions and is as widespread as presumed, this therapeutic approach is neither an efficient nor effective way to help large numbers of people. Moreover, if, as the literature suggests, many of the factors associated with the formation of negative math attitudes grow out of classroom experiences, the classroom might be the appropriate site of redress: thus, MART was initiated.

MART's first-year goal was to improve the climate for the learning of mathematics and induce a more positive response on the part of students

through: increasing community college instructors' awareness of and sensitivity to students' feelings about math; providing selected faculty with a supervised and structured opportunity to explore their own attitudes and behavior as these may affect students' reactions and performance; and, with the help of experts, demonstrating new pedagogical strategies and techniques that faculty might adapt to their own classroom situations.

As a pilot demonstration, IRDOE implemented two workshop series. The first-cycle involved 16 faculty from one college's regular math and developmental (i.e., remedial math) skills department, together with their respective chairpeople. This group met for eight 2-1/2 hour sessions on Tuesday afternoons on the college campus. The second workshop series was held on four consecutive Saturdays at IRDOE's offices at the CUNY Graduate School and University Center. Each of these sessions was five hours long, and involved (on a regular basis) 14 faculty (math and physics) and staff (guidance) from four CUNY community colleges and one private four-year college in New York City.

All of the participants had advanced degrees and most had an undergraduate major in mathematics. The Tuesday and Saturday groups had an average of 11.7 and 8.1 years, respectively, of college teaching experience, and concluding from the fact that the majority had or were obtaining additional training in math education, they intended to remain on the staff of the two-year colleges. Although most were happy with their current teaching assingments, they had chosen mathematics as a profession because they enjoyed the subject and did well in it.

Each group experienced the workshop program differently and evinced very different reactions to it. In general, the Saturday group--perhaps because they were so very self-selected--was livelier, warmer, and more enthusiastic: they were easier to engage and apparently more responsive and open to suggestions. On most ratings they judged MART more useful and more helpful than did the first-cycle participants. In turn, the Tuesday

group manifested less overt enthusiasm and appeared more critical and less responsive and open to suggestions. In absolute terms, however, they too rated MART as useful and benefitted from participation.

As a matter of fact, in many instances, the attitudes of the Tuesday group improved in the desired directions more dramatically than did the attitudes of those who took part in the Saturday cycle. Some of this was an artifact of measurement, due to the initially more positive ratings of the participants in the second series. Not all the attitudinal changes can be accounted for in this way, however, and probably represent real gains. We, of course, cannot determine whether these will be translated into new behavior in the classroom, but participants in both groups did talk about some of the things they had actually tried out. At the very least, the evidence clearly points to an increased awareness of and sensitivity to the needs of math anxious/math avoiding students and to the disparities between how these students and their instructors view mathematics.

At this time we also cannot determine whether participants will engage in any of the followup activities we initiated at the final workshop session(s). There is no question that math anxiety is prevalent among community college students. The results of the mathematics anxiety self-rating scale we administered with the assistance of volunteer participants illuminate how widespread math anxiety is--especially in remedial classes and among women students. That there is the need for some sort of intervention is evident, but without a followup study it is not possible to know whether, for example, a group of Tuesday faculty actually got together to refocus the departments' math lab (with or without attempting to write a proposal for funding), or whether the Saturday participants individually tried to influence the ideas of colleagues at their colleges.

In conclusion, there is strong and sufficient evidence that community college students (regardless of level of performance) experience moderate to high level math anxiety; that math anxiety interferes with achievement;

and that without an adequate background in mathematics, students'--especially women students'--career options will continue to be restricted.

Following directly from this is a need for faculty and staff of community colleges to better understand math anxious/math avoiding students, in order to work effectively with them. Because of the extent and intensity of the problem, an approach similar in premise to that underlying Project MART is recommended. The scope of math anxious / math avoiding behavior requires a programmatic response that is more massive and cost-effective than the student-as-patient model. It is our belief that MART meets the criteria of:

- efficiency and effectiveness--by providing training to fairly large numbers of faculty who, in turn, work directly with large numbers of students;
- need--in addition to becoming more aware of the needs of the math anxious student, MART meets community college faculty needs for more background in pedagogy and the psychology of learning;
- relevance--the MART model, with its emphasis on new classroom techniques, is a more relevant solution to the problem of students' negative attitudes since it addresses the genesis of these attitudes;
- generalizability--thus, as a prototype, MART has the potential for adaption to similar needs of community college faculty in other disciplines, especially science; and
- promise for the future--by exposing instructional faculty to the more recent developments in the field of math education, MART supplements the expanding pre-service educational programs for new teachers. Both in-service and pre-service approaches hold the greatest promise for the improved education of the students of tomorrow.

More work has to be done on the MART curriculum. For example, faculty want and need more information and more specific applications pertaining to the psychology of learning, the purpose of testing,and the construction

of tests, and course construction and the sequential ordering of topics. They would also welcome specific, innovative, and anxiety-reducing ways of: teaching specific concepts and calculations; improving students' concern for accuracy; managing a classroom; and helping students understand the importance of mathematics in today's world.

MART-type workshops are perhaps best conducted in a central location with faculty from several colleges. Administrators should be discouraged as regular participants, although they may serve an important resource function. Attendance should be limited to approximately 15 participants, with no more than one to two of them being counselors. Full-day sessions can be considered, but the workshop group should meet on a regular schedule at least 6 to 10 times; with an expanded curriculum it should be possible to maintain a high level of interest, involvement, and motivation.

At present, the Project MART model is recommended because of the extent of math anxiety, the minimal training most college instructors have in pedagogical technique and style, and because of the newness of the literature on the relationship between negative attitudes in math and learning behavior. Ultimately, it should be feasible to alter or abandon the workshop format and substitute other approaches. In the interim, the staff of Project MART strongly recommends additional work with this model and with these target populations of students and teachers. At the same time, we would also like to see other forms of communication initiated (e.g., self-instructional materials for teachers) that have the capability of meeting the needs of more people more quickly.

APPENDIX A

AGENDA: COLLEGE ORIENTATION MEETINGS.....A1

APPENDIX A

CASE/Institute for Research and Development in Occupational Education
The Graduate School and University Center
of the City University of New York

Project MART: Math Avoidance Reduction Training
1979-80

AGENDA: COLLEGE ORIENTATION

1. Who we are: Barbara R. Heller, Project Director

   - CASE/IRDOE
   - Project MART Staff
   - Prior cooperative efforts

2. Project background: Victor D'Lugin, Project Associate

   - NSF Workshop
   - Career Paths planning. Supplemental activities, Prong II
   - from SENIOR to FRESHMAN...

3. Mathematics and the community college career programs: Carol Florio, Staff Associate

   - Math enrollment
   - Math avoidance and career implications

4. Project MART: Barbara R. Heller

   - Program goals
   - Outcomes and benefits

5. Math anxiety: Dr. Stanley Kogelman, Director of "Mind Over Math"

   - Why people are math anxious
   - Summary of others' programs and approaches
   - Project MART content description

6. MART structure and organization: Victor D'Lugin

   - IRDOE's and participants' commitments
   - Scheduling and participation

7. Next steps: Barbara R. Heller

APPENDIX B

RESULTS OF THE MARS-A

TABLE B1 MEAN SCORES OF MALE & FEMALE STUDENTS ON THE MARS-A: MATH SECTIONS/COURSES TAUGHT BY SECOND-CYCLE PARTICIPANTS. B1

TABLE B2 MEAN SCORES OF MALE & FEMALE STUDENTS ON THE MARS-A: MATH SECTIONS/COURSES TAUGHT BY FIRST-CYCLE PARTICIPANTS. B2

TABLE B2

MEAN SCORES OF MALE AND FEMALE STUDENTS ON THE MARS-A:

MATH SECTIONS/COURSES TAUGHT BY SECOND-CYCLE PARTICIPANTS

COURSE (No. of Sections)	TOTAL (MALES + FEMALES)				MALES			FEMALES			Difference[c] (F - M)
	N	Average[a] Raw Score	Range	Average[b] Scale Score	N	Average Raw Score	Average Scale Score	N	Average Raw Score	Average Scale Score	
Remedial Math (5)	47	237	1.11-4.03	2.42	12	183	1.86	35	236	2.41	+0.55
Introductory Math (3)	45	235	1.20-4.03	2.40	6	190	1.94	39	230	2.35	+0.41
Algebra (2)	25	206	1.09-3.88	2.10	12	207	2.11	13	209	2.13	+0.02
Arithmetic (1)	13	199	1.35-3.07	2.03	13	199	2.03	0	0	0	--
Calculus (1)	8	244	1.42-3.64	2.49	7	228	2.32	1	357	3.64	+1.32
Math-on-the-job (1)	11	250	1.69-3.90	2.55	0	0	0	11	250	2.55	--
Math Workshop(1)	8	273	1.29-3.19	2.78	2	220	2.24	6	290	2.96	+0.72
Physics 12 (1)	23	177	1.11-3.53	1.80	14	168	1.72	9	189	1.93	+0.21

[a]From Suinn, Raw score percentile equivalents:

Percentile	Raw Score	Percentile	Raw Score
5%	120	50	176
10	127	60	192
20	135	75	217
30	144	80	224
40	153	95	278

[b]Average scale-score = Raw score ÷ N items completed.

[c]Difference scores: a + difference = females score higher than males.

TABLE D2

MEAN SCORES OF MALE AND FEMALE STUDENTS ON
THE MARS-A: MATH SECTIONS/COURSES TAUGHT BY FIRST-CYCLE PARTICIPANTS

COURSE (No. of Sections)	TOTAL (MALES + FEMALES)				MALES			FEMALES			Difference[c.] (F - M)
	N	Average Raw Score[a.]	Range	Average Scale Score[b.]	N	Average Raw Score	Average Scale Score	N	Average Raw Score	Average Scale Score	
Remedial - 1 (4)	76	245	1.10-4.92	2.50	25	233	2.38	51	251	2.56	+0.18
Remedial - 2 (6)	121	239	1.13-4.69	2.44	51	232	2.37	70	224	2.49	+0.12
Developmental Math Total (10)	197	241	1.10-4.92	2.46	76	232	2.37	121	247	2.52	+0.15
Fundamentals (4)	91	205	1.04-3.54	2.09	63	201	2.05	28	214	2.18	+0.13
Algebra Trig. (2)	34	205	1.04-3.85	2.09	20	212	2.17	14	195	1.99	-0.18
Precalculus (2)	45	202	1.00-3.59	2.06	30	208	2.12	15	189	1.93	-0.19
Calculus + Anal. Geom. (2)	20	201	1.03-3.38	2.05	17	183	1.87	3	302	3.08	+1.21
Regular Math Total (10)	190	204	1.00-3.85	2.08	130	202	2.06	60	208	2.12	+0.06

[a]From Suinn, Raw score percentile equivalents:

Percentile	Raw Score	Percentile	Raw Score
5%	120	50	176
10	127	60	192
20	135	75	217
30	144	80	224
40	153	95	278

[b]Average scale-score = Raw score ÷ N items completed.

[c]Difference scores: a + difference = females score higher than males.

APPENDIX C

QUESTIONNAIRES

FACULTY OPINION SURVEY, PRETEST.....C1

FACULTY FOLLOW-UP SURVEY, POSTTEST.....C6

CASE: Institute for Research and Development in Occupational Education
Graduate School and University Center
City University of New York

Project MART: FACULTY OPINION SURVEY, 1979-1980

This opinionnaire is designed specifically for mathematics faculty. It consists of 3 sections:your teaching preferences and experiences, beliefs and classroom styles, and your own background and experiences as a student.

The purpose of this instrument is two-fold: First, consider it a technique for elucidating some of the feelings and perceptions we hold as mathematicians; as such, it will provide us as workshop participants with a starting point--a common basis for discussing events that take place in the classroom. Second, it will provide essential information which, together with your responses to other questions we will ask periodically throughout the workshop, will enable us to evaluate MART's effectiveness.

This opinionnaire will be collected at the end of today's session; blank copies of this form are available for those who would like one. Although we guarentee anonymity and confidentiality of individuals, we need to be able to identify the same respondent to later questions. Therefore, please code your opinionnaire by using the last 4 digits of your Social Security number. We appreciate your cooperation. Thank you.

Please enter those 4 digits here: _____

SECTION 1: TEACHING PREFERENCES

1. What math courses do you most prefer teaching? _____

_____

2. What math courses do you least like to teach? _____

_____

3. Please indicate your preference for teaching the following types of students and courses:

	Prefer to teach	Don't mind	Do not enjoy
Remedial students			
Average students			
Bright students			
Bilingual students			
Pre-high school			
High School			
Community college			
Four-year college			
Graduate school			

4. We are interested in whether, in your experience, male and female students differ with respect to their performance in mathematics and in their behavior in the classroom. For each item below, circle the M or F to indicate who generally performs the task better or is more likely to engage in the behavior.

Arithmetic.	M	F	Willing to work at the blackboard.	M	F
Fractions	M	F	Asks questions during class.	M	F
Word problems . . .	M	F	Asks questions after class	M	F
Geometry.	M	F	Completes homework assignments	M	F
Trigonometry. . . .	M	F	Attends class regularly.	M	F
Algebra	M	F	Answers questions in class	M	F
Statistics.	M	F	Is nervous in class.	M	F
Calculus.	M	F	Is nervous taking tests.	M	F

SECTION II. BELIEFS AND PRACTICES

1. Listed below are a number of statements. Please rate how important you feel each is in being an effective teacher of mathematics.

	Not Important At All	Somewhat Unimportant	Somewhat Important	Very Important
Knowledge of math history				
Knowledge of math folklore				
Arithmetic skill (calculations)				
Pedagogical technique				
Knowledge of the psychology of learning				
Preference for the specific subject				
Competence in the specific subject				
Knowledge of mathematical research issues				
Membership in professional organizations and assocaitions				
Knowledge of students' feelings				
Knowledge of how math relates to other subject areas				

2. For each of the following statements, please indicate how you feel.	Strongly Disagree	Disagree Somewhat	Agree Somewhat	Strongly Agree
Generally there is only one good way to solve a math problem.				
Instructors should tell students the difficulties they themselves have in math.				
Math is a subject that one either knows or doesn't know.				
A good mathematical solution is elegant.				
Math is nice because it permits one to evaluate his/her own accomplishments.				
Math is neat and tidy.				
It is important to present single, clear, unambiguous solutions to math problems.				
Calculators should not be used in class.				
Students should keep working on a problem until they find the solution.				
Elementary school pupils should be discouraged from counting on their fingers.				
It doesn't matter how they do it as long as students get the right answer.				
Math is not creative.				
Some people have a "math mind" and some don't.				

3. The following factors are believed to contribute to the solution of difficult math problems. Rate each.	Not Important At All	Somewhat Unimportant	Somewhat Important	Very Important
Ability to do arithmetic calculations				
Knowing basic mathematical concepts				
Knowing how others did the problem				
Knowing what has failed in previous attempted solutions				
Logic				
Intuition or guessing				
Perserverence				
Practicing similar, but easier problems				

4. Many factors go into computing a student's grade. Please indicate how you feel about each.	Not Important At All	Somewhat Unimportant	Somewhat Important	Very Important
Performance on the final				
Performance on the mid-term				
Performance on quizzes				
Participation in class				
Completion of homework				
Student's general ability level				
The effort the student makes				
The student's general attitude				
Your general impression				
Departmental policy				

5. Below are two math problems similar to ones that you might include on an exam in one of your courses. For each problem three typical solutions are given, all of which have incorrect answers. The maximum credit for each problem is 10 points. Please indicate how you would grade each solution by scoring each from 0 to 10.

Problem A: BILL HAS $5.05 IN DIMES AND QUARTERS. IF THE NUMBER OF QUARTERS EXCEEDS TWICE THE NUMBER OF DIMES BY ONE, FIND THE NUMBER OF COINS OF EACH TYPE.

Solution #1

10 quarters = $2.50
20 quarters = $5.00

18 quarters = $4.50, 5 dimes = 50¢, total = $5.00

SCORE: _____ POINTS

Solution #2

Let no. dimes = d
Let no. quarters = $2d-1$
value of dimes = $10d$
value of quarters = $25(2d-1)$

$10d + 25(2d-1) = 505$
$10d + 50d - 25 = 505$
$60d = 480$
$d = 8$
$2 = 15$

15 quarters, 8 dimes

SCORE: _____ POINTS

Solution #3

total coins = $5.05
dimes = $10N$
quarters = $25(2N+1)$

$10N + 25(2N+1) = 505$
$10N + 50N + 25 = 505$
$60N = 540$
$N = 9$
$2 = 19$

19 quarters, 9 dimes

SCORE: _____ POINTS

Problem B: SOLVE FOR a : $-25 = \frac{7}{3}a - 11$

Solution #1

$-25 = \frac{7}{3}a - 11$

$+11 \qquad +11$

$-36 = \frac{7}{3}a$

$\frac{3}{7}(-36) = \frac{7}{3}a\left(\frac{3}{7}\right)$

$a = 5\frac{1}{7}$

SCORE:_____points

Solution #2

$3 \cdot -25 = \frac{7}{3}a - 11 \cdot 3$

$-75 = 7a - 11$

$+11 \qquad +11$

$-\frac{64}{7} = \frac{7a}{7}$

$a = -9\frac{1}{3}$

SCORE:_____points

Solution #3

$-25 = \frac{7}{3}a - 11$

$+11 \qquad +11$

$3 \cdot -14 = 3 \cdot \frac{7}{3}a$

$\frac{42}{7} = \frac{7a}{7}$

$a = 6$

SCORE:_____points

SECTION III. DEMOGRAPHIC INFORMATION

1. What was your undergraduate: Major?_____ Minor?_____

2. What is your highest earned degree?

☐ AB/BS ☐ MA/MS ☐ Ph.D./Ed.D. ☐ Other; specify:_____

In what field?_____

3. Are you currently pursuing another degree? ☐ No ☐ Yes; if yes, what degree?_____

What field?_____

4. Please list the courses you currently teach: _____

_____

5. What kinds of students are you now teaching? ☐ Remedial ☐ Average ☐ Advanced

AND ☐ High school-aged ☐ College level ☐ Adults ☐ Other;specify:_____

6. When (at what age and/or grade level) did you first decide that you were interested in mathematics as a profession?_____

_____

7. Please describe the feelings, event(s), or experiences underlying your personal decision to pursue a career in mathematics:_____

_____

_____

8. When you were in high school, how did you feel about each of the following subjects?

	Strongly Disliked	Disliked	Liked	Strongly Liked
English and literature				
Foreign Language				
Physical, chemical sciences				
Biological, natural sciences				
Mathematics				
History and the social sciences				

9. In general, how would you describe your high school math instructors?

Boring ___ ___ ___ ___ ___ ___ Interesting
Excellent ___ ___ ___ ___ ___ ___ Poor
Warm ___ ___ ___ ___ ___ ___ Cold
Indifferent ___ ___ ___ ___ ___ ___ Concerned

10. In general, how would you describe your college math instructors?

Boring ___ ___ ___ ___ ___ ___ Interesting
Excellent ___ ___ ___ ___ ___ ___ Poor
Warm ___ ___ ___ ___ ___ ___ Cold
Indifferent ___ ___ ___ ___ ___ ___ Concerned

11. What was the lowest grade you ever received in a math course? _____
What course? _____

12. As a student, what math course(s) did you find most difficult? _____

_____

13. Did you ever drop or withdraw from a math course? ☐ No ☐ Yes; if yes, what course(s) and why did you drop it or withdraw? _____

_____

14. As a student taking tests (not math), were you generally:

☐ Very relaxed ☐ Somewhat relaxed ☐ Somewhat anxious ☐ Very anxious

15. As a student taking math tests, were you generally:

☐ Very relaxed ☐ Somewhat relaxed ☐ Somewhat anxious ☐ Very anxious

16. How frequently did (do) you feel like giving up your study of math?

☐ Very rarely ☐ Somewhat rarely ☐ Somewhat often ☐ Very often

17. How frequently do (did) you feel like giving up the teaching of math?

☐ Very rarely ☐ Somewhat rarely ☐ Somewhat often ☐ Very often

18. Do you anticipate a change in career--either away from math or away from teaching math--in the future? ☐ No ☐ Yes

CASE/Institute for Research and Development in Occupational Education
Graduate School and University Center
City University of New York

Project MART: FACULTY FOLLOW-UP SURVEY, 1979-1980

This opinionnaire, designed specifically for mathematics faculty, is similar to the one we asked you to complete at the beginning of the MART workshop series. It is intended to provide essential information which, along with other data, will enable us to evaluate the program's impact.

We guarantee anonymity and confidentiality of individual responses, but since we are interested in comparing your own responses before and after, we are asking you to identify yourself using the last four digits of your Social Security number. We appreciate your cooperation. Thank you.

Please enter the last four digits of your S.S. # here:_____

1. For how many years have you been teaching at the college level?_____

2. For each of the following statements, check a column to indicate how you feel.

	Strongly Disagree	Disagree Somewhat	Agree Somewhat	Strongly Agree
Generally there is only one good way to solve a math problem.				
Instructors should tell students the difficulties they themselves have in math.				
Math is a subject that one either knows or doesn't know.				
A good mathematical solution is elegant.				
Math is nice because it permits one to evaluate his/her own accomplishments.				
Math is neat and tidy.				
It is important to present single, clear, unambiguous solutions to math problems.				
Calculators should not be used in class.				
Students should keep working on a problem until they find the solution.				
Elementary school pupils should be discouraged from counting on their fingers.				
It doesn't matter how they do it as long as students get the right answers.				
Math is not creative.				
Some people have a "math mind" and some don't.				

3. Listed below are a number of statements. Please rate how important you feel each is in being an effective teacher of mathematics.

	Not Important At All	Somewhat Unimportant	Somewhat Important	Very Important
Knowledge of math history				
Knowledge of math folklore				
Skill at arithmetic calculations				
Pedagogical technique				
Knowledge of the psychology of learning				
Preference for the specific subject				
Competence in the specific subject				
Knowledge of mathematical research issues				
Membership in professional organizations and associations				
Knowledge of students' feelings				
Knowledge of how math relates to other subject areas				

4. The following factors are believed to contribute to the solution of difficult math problems. Rate each.

	Not Important At All	Somewhat Unimportant	Somewhat Important	Very Important
Ability to do arithmetic calculations				
Knowing basic mathematical concepts				
Knowing how others did the problem				
Knowing what has failed in previous attempted solutions				
Logic				
Intuition or guessing				
Perseverance				
Practicing similar, but easier problems				

5. Many factors go into computing a student's grade. Please indicate how you feel about each.

	Not Important At All	Somewhat Unimportant	Somewhat Important	Very Important
Performance on the final				
Performance on the mid-term				
Performance on quizzes				
Participation in class				
Completion of homework				
Student's general ability level				
The effort the student makes				
The student's general attitude in class				
Your general impression				
Departmental policy				

6. Below are two math problems similar to ones that you might include on an exam in one of your courses. For each problem three typical solutions are given, all of which have incorrect answers. The maximum credit for each problem is 10 points. Please indicate how you would grade each solution by scoring each from 0 to 10.

Problem A: BILL HAS $5.05 IN DIMES AND QUARTERS. IF THE NUMBER OF QUARTERS EXCEEDS TWICE THE NUMBER OF DIMES BY ONE, FIND THE NUMBER OF COINS OF EACH TYPE.

Solution #1

10 quarters = $2.50
20 quarters = $5.00

18 quarters = $4.50, 5 dimes = 50¢
total = $5.00

15 quarters = $3.75, 13 dimes = $1.30
total = $5.05

ans 15 quarters, 13 dimes

SCORE:_____POINTS

Solution #2

Let no dimes = d
Let no quarters = 2d - 1
value of dimes = 10d
value of quarters = 25(2d-1)

$10d + 25(2d-1) = 505$
$10d + 50d - 25 = 505$
$60d = 480$
$d = 8$
$8 = 15$

ans 15 quarters, 8 dimes

SCORE:_____POINTS

Solution #3

total coins = $5.05
dimes = $10N$
quarters = $25(2N+1)$

$10N + 25(2N+1) = 505$
$10N + 50N + 25 = 505$
$60N = 540$
$N = 9$
$8 = 19$

ans. 19 quarters, 9 dimes

SCORE:_____POINTS

Problem B: SOLVE FOR a: $-25 = \frac{7}{3}a - 11$

Solution #1

$-25 = \frac{7}{3}a - 11$
$-11 \quad -11$
$-36 = \frac{7}{3}a$
$\frac{3}{7}(-36) = \frac{7}{3}a\left(\frac{3}{7}\right)$
$a = 5\frac{1}{7}$

SCORE:_____POINTS

Solution #2

$3 \cdot -25 = \frac{7}{3}a - 11 \cdot 3$
$-75 = 7a - 11$
$+11 \quad +11$
$-\frac{64}{7} = \frac{7a}{7}$
$a = -9\frac{1}{3}$

SCORE:_____POINTS

Solution #3

$-25 = \frac{7}{3}a - 11$
$+11 \quad +11$
$3 \cdot -14 = 3 \cdot \frac{7}{3}a$
$\frac{42}{7} = \frac{7a}{7}$
$a = 6$

SCORE:_____POINTS

7. In general, how much did MART help you understand, or stimulate you to consider:

	Not at all Helpful	Not very Helpful	Somewhat Helpful	Very Helpful
the needs of the math anxious student				
your grading criteria				
your testing strategy				
your teaching techniques				
your students' reactions to you				
your expectations for your students				
how to identify the math anxious student				
your understanding of how much your students know				
the way you teach fractions				
the way you teach algebra				
the way you teach word problems				
the way you teach sign numbers				
how much you as a mathematician take for granted				

8. Project MART prepared and distributed materials for you to read; each piece is listed below. Please indicate how useful you found the materials.

	Haven't read it yet	Not at All	Not Very	Somewhat	Very
The research article summarizing sex differences and other affective variables					
The collection of cartoons and the discussion of how mathematicians are perceived					
Characteristics of the Math Anxious Student					
The Bibliography summarizing selected research on math anxiety					
Math Myths and Their Implications					
The direct translation method for approaching word problems					
The "toy boat" problem					
The chauvanistic movie ticket problem					
Kogelman and Warren's Mind Over Math					
The MARS-A (student rating scale) and results					
The description of the Fennema-Sherman Math Test					
Thoughts on Teaching Fractions					
Tips on Tests, Testing, & Class Preparation					
Thoughts on Teaching Algebra					
Thoughts on Teaching Sign Numbers					
Grading					
How to Read Math Books					
Evaluating Math Texts					
Do's and Dont's in the Classroom					

9. Compared with other workshop-type programs in which you participated or heard about from others, how would you rate MART? Overall, MART was:

	Not at all	Not very	Somewhat	Very
Worthwhile				
Relevant				
Interesting				
Thought provoking				
Well planned				
Well organized				